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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

## ITU-T L.1410 – Example of hybrid life cycle assessment of the aggregated second order effects of selected information and communication technology services

ITU-T  L-series Recommendations  –  Supplement 34

ITU-T L-SERIES RECOMMENDATIONS

**ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT**

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# Supplement 34 to ITU-T L-series Recommendations

# ITU-T L.1410 – Example of hybrid life cycle assessment of the aggregated second order effects of selected information and communication technology services

**Summary**

Supplement 34 to ITU-T L-series Recommendations presents three case studies of the life cycle assessment (LCA) of the second order effects of some selected information and communication technology (ICT) services running upon three different primary subscription services: the 4th Generation Long Term Evolution (4G LTE) service, the 3rd Generation Wideband Code Division Multiple Access (3G W-CDMA) service, and an optical fixed Internet protocol (IP) network (broadband NW), all provided by Nippon Telegraph and Telephone Corporation (NTT) groups in Japan.

The goal of these case studies is to clarify the second order effects per private subscriber of the ICT services in compliance with ITU-T L.1410 for the assessed ICT services. The second order effects of each target scenario, e.g., e-mail, video/music on demand and games, provided by each ICT service are evaluated by comparative analyses between each target scenario and corresponding reference scenarios, which are defined as a private subscriber's behaviour when not using an ICT service. Both scenarios are defined in a questionnaire investigation given to users. The total second order effects per subscriber for each ICT service are obtained by aggregating the results of these comparative analyses based on hybrid LCA.

**History**

| Edition | Recommendation | Approval | Study Group | Unique ID* |
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**Keywords**

4th generation long term evolution (4G LTE), 3rd generation wideband code division multiple access (3G W-CDMA), comparative analysis, ICT services, information and communication technologies (ICTs), input–output analysis (IOA), optical fixed IP network (broadband NW), public switched telephone network (PSTN), second order effect.

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* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11 830-en.

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# Supplement 34 to ITU-T L-series Recommendations

## ITU-T L.1410 – Example of hybrid life cycle assessment of the aggregated second order effects of selected information and communication technology services

## 1      Scope

This Supplement provides an example of the life cycle assessment (LCA) of information and communication technology (ICT) services and networks, especially for the second order effects of network-based ICT services, such as e-mail, video/music on demand and games.

This Supplement presents case studies of the LCA of the second order effects per private subscriber of some selected ICT services running upon three different primary subscription services: the 4th Generation Long Term Evolution (4G LTE) service, the 3rd Generation Wideband Code Division Multiple Access (3G W-CDMA) service and an optical fixed Internet protocol (IP) network (broadband NW), all provided by Nippon Telegraph and Telephone Corporation (NTT) groups in Japan. The assessments were performed as comparative analyses in line with [ITU-T L.1410] through a hybrid approach combining elements of process-sum and environmentally extended economic input-output (IO) LCAs.

Scenarios for comparison were based on the results of a customer questionnaire.

## 2      References

| [ITU-T L.1410] | Recommendation ITU-T L.1410 (2014), *Methodology for environmental life cycle assessments of information and communication technology goods, networks and services*. |
|---|---|
| [ISO 14040] | ISO 14040:2006, *Environmental management – Life cycle assessment – Principles and framework*. |
| [ISO 14044] | ISO 14044:2006, *Environmental management – Life cycle assessment – Requirements and guidelines*. |

## 3      Definitions

None.

## 4      Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

| | |
|---|---|
| 4G LTE | 4th Generation Long Term Evolution |
| 3G W-CDMA | 3rd Generation Wideband Code Division Multiple Access |
| ATM | Automated Teller Machine |
| CD | Compact Disc |
| CFP | Carbon Footprint |
| DVD | Digital Versatile Disc |
| EoLT | End-of-Life Treatment |
| GHG | Greenhouse Gas |
| GWP | Global Warming Potential |

| | |
|---|---|
| ICT | Information and Communication Technology |
| ID | Identifier |
| IO | Input–Output |
| IOA | Input–Output Analysis |
| IP | Internet Protocol |
| LCA | Life Cycle Assessment |
| LCI | Life Cycle Impact |
| LCIA | Life Cycle Impact Assessment |
| NW | Network |
| PC | Personal Computer |
| RBS | Radio Base Station |
| RMA | Raw Material Acquisition |
| PSTN | Public Switched Telephone Network |
| SNS | Social Network Service |
| TV | Television |

## 5 Methodological framework

### 5.1 Evaluation procedure

The evaluation procedure (see Figure 1) is:

– select target scenarios and corresponding reference scenarios for comparative analyses by customer questionnaire;

– execute the comparative analysis of each scenario in line with [ITU-T L.1410];

– aggregate each result to obtain total second order effects of the assessed target scenarios.
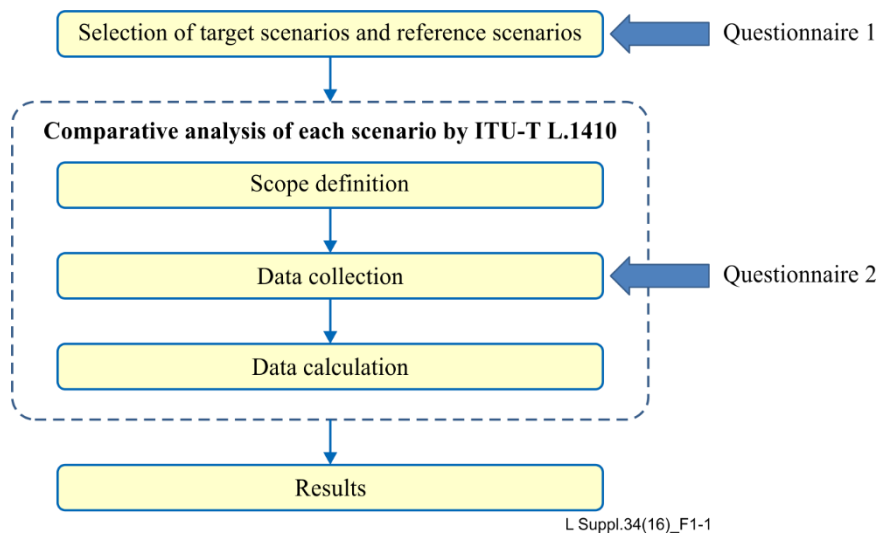


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**Figure 1-1 – Evaluation procedure**

## 5.2    Goal and scope definition

### 5.2.1    Goal of the study

The purpose of this case study is to provide an example of the LCA of ICT services and networks, especially for the second order effects of network-based ICT services, e.g., e-mail, video/music on demand and games.

The goal of these case studies is to clarify the second order effects per private subscriber of some selected ICT services running upon three different primary subscription services: the 4th Generation Long Term Evolution (4G LTE) service, the 3rd Generation Wideband Code Division Multiple Access (3G W-CDMA) service and an optical fixed IP network (broadband NW), all provided by Nippon Telegraph and Telephone Corporation (NTT) groups in Japan. Scenarios for comparison were based on the results of a customer questionnaire. In this case study, a hybrid approach that includes environmentally extended economic input–output analysis (IOA) for production and end-of life was applied.

### 5.2.2    Scenarios for comparison

Figures 1-2 and 1-3 show model diagrams of target scenarios and reference scenarios, respectively.

NOTE – The target scenarios for mobile networks only include access by smartphones (for LTE) and feature phones (for W-CDMA). This is a simplification as in reality networks are also accessed by other devices such as personal computers (PCs), laptops and tablets; additionally, different types of phones may be used on both networks.
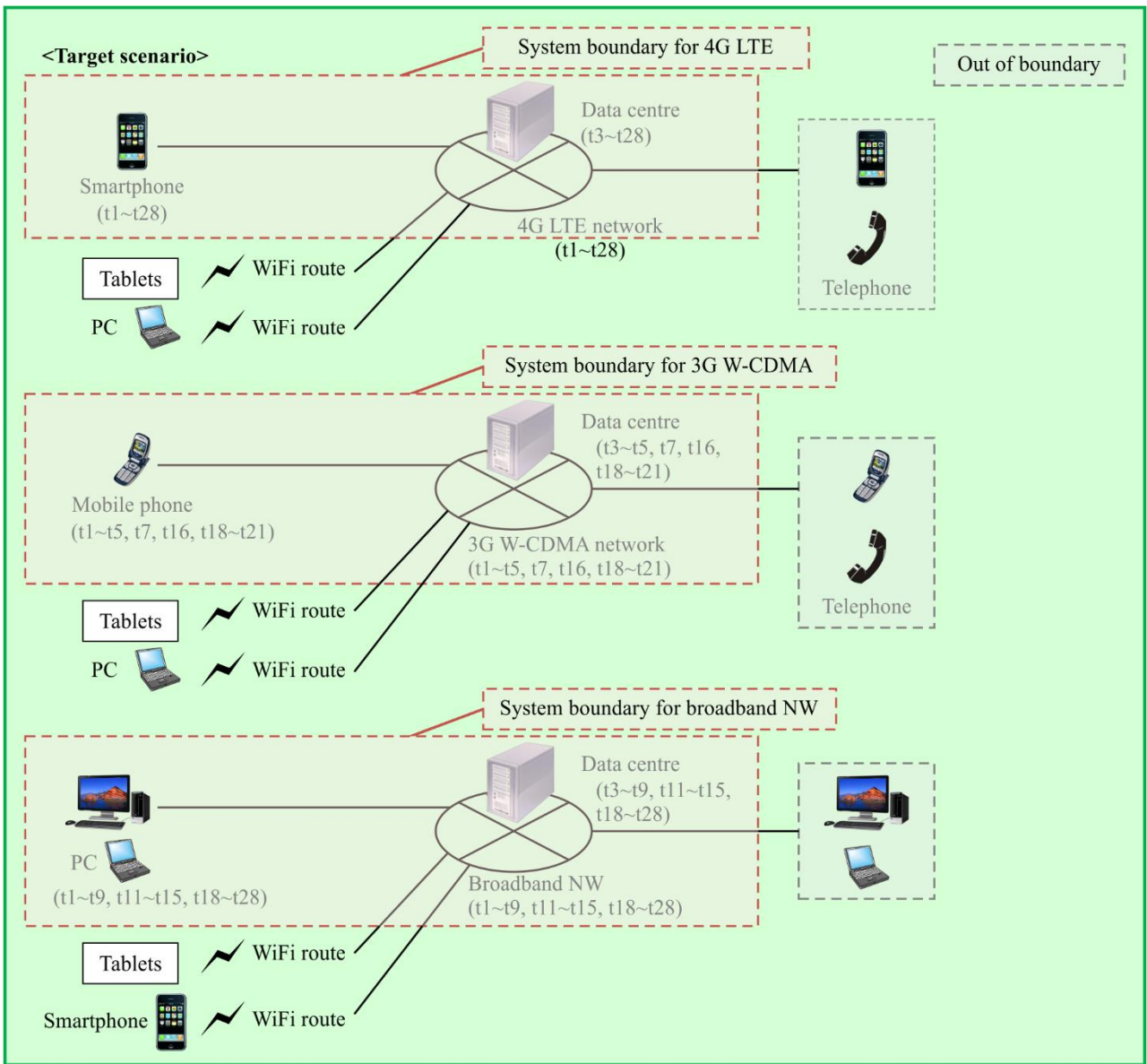
**Figure 1-2 – Target scenario**

NOTE – Symbols tn (n = 1–28) correspond to target scenario identifiers (IDs) in Table1-1.
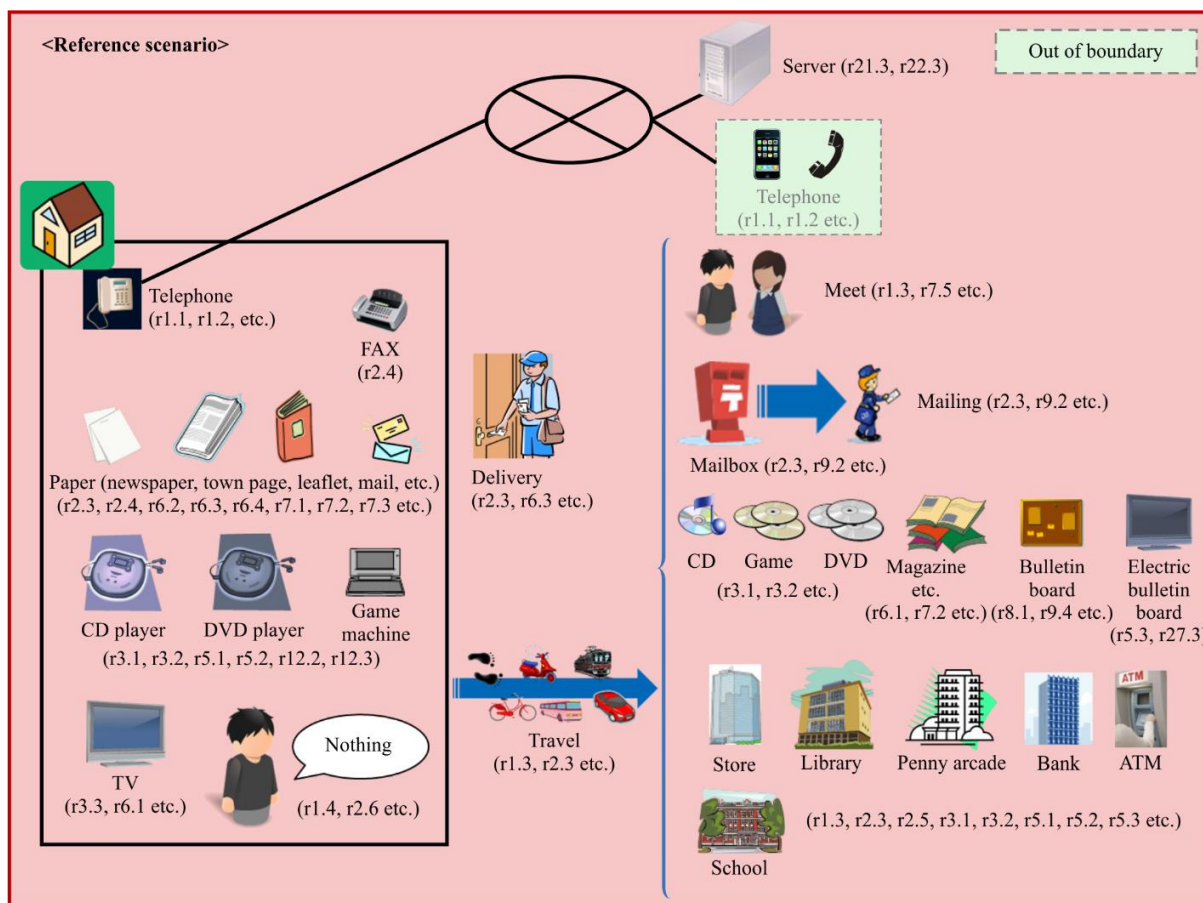
Figure 1-3 – Reference scenario

NOTE – Symbols r*n* (*n* = 1–28) correspond to reference scenario IDs in Table1-1.

Scenarios for comparison were based on the results of questionnaire 1 for private customers of each ICT service, which are shown in Table 1-1.

In the reference scenario, users utilize different devices, e.g., paper, compact disc (CD) players or televisions (TVs), to perform different services/functions, e.g., meeting or sending mail. For each function, the usage per year is modelled based on the anticipated use of these services if no ICT service were available, based on a questionnaire on which private customers estimate what they would have done in that case. Usage per year was checked for all ICT services. As an example, for the function "talk to someone", users were asked whether they would use a home telephone or a public phone, meet in person or do nothing if they could not have used the smartphone, for example. Based on the responses, the reference scenario was set up. To model this scenario each function was represented by the greenhouse gas (GHG) emissions associated with the equipment used to perform the alternative activity. For example, "using a home phone" was modelled on the impact of the ICT hardware needed for use and "meeting someone" on the transport needed, as further specified in clause 5.2.4. In total, 121 reference cases were defined.

The allocation of equipment impact to different functions was based on usage time, as experienced by the user, e.g., time spent on a phone call.

The usage of different ICT services in the target scenarios were defined by statistics from the Ministry of Internal Affairs and Communications in Japan, which shows the actual use of each ICT service. Each ICT service was then modelled, based on impact of the equipment needed to perform the services, as specified in clause 5.2.4. Also, in this case, the allocation of equipment impact on the different functions was based on usage time.

The results of the questionnaire are shown in Appendix III.

**Table 1-1 – Target and reference scenarios**

| Function | Mobile network | | Broadband NW | Target scenario | | Reference scenario | |
|---|---|---|---|---|---|---|---|
| | 4G LTE | 3G W-CDMA | | ID | | ID | |
| Talk with someone | ○ | ○ | ○ | t1 | Voice calls | r1.1 | Use home telephone |
| | | | | | | r1.2 | Use public telephone |
| | | | | | | r1.3 | Meet |
| | | | | | | r1.4 | Do nothing |
| Transmit messages | ○ | ○ | ○ | t2 | Email | r2.1 | Use home telephone |
| | | | | | | r2.2 | Use public telephone |
| | | | | | | r2.3 | Letter |
| | | | | | | r2.4 | Fax |
| | | | | | | r2.5 | Meet |
| | | | | | | r2.6 | Do nothing |
| Listen to music | ○ | ○ | ○ | t3 | Music | r3.1 | Purchase CD |
| | | | | | | r3.2 | Rent CD |
| | | | | | | r3.3 | Watch TV, Listen to radio |
| | | | | | | r3.4 | Do nothing |
| Set smartphone wallpaper | ○ | ○ | ○ | t4 | Images | r4.1 | Do nothing |
| Play games | ○ | ○ | ○ | t5 | Games | r5.1 | Purchase game software |
| | | | | | | r5.2 | Rent game software |
| | | | | | | r5.3 | Play at arcade |
| | | | | | | r5.4 | Do nothing |
| Read and watch entertainment and sports news | ○ | | ○ | t6 | Entertainment and sports news | r6.1 | Watch TV, listen to radio |
| | | | | | | r6.2 | Read books, magazines |
| | | | | | | r6.3 | Read newspaper |
| | | | | | | r6.4 | Read hanging poster |
| | | | | | | r6.5 | Do nothing |
| Search for information | ○ | ○ | ○ | t7 | Search and link aggregation | r7.1 | Search in library |
| | | | | | | r7.2 | Search with own books |
| | | | | | | r7.3 | Purchase books, magazines |
| | | | | | | r7.4 | Ask on telephone |
| | | | | | | r7.5 | Meet and ask |
| | | | | | | r7.6 | Do nothing |

**Table 1-1 – Target and reference scenarios**

| Function | Mobile network | | Broadband NW | Target scenario | | Reference scenario | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | 4G LTE | 3G W-CDMA | | ID | | ID | |
| Get unspecified number of onion | ○ | | ○ | t8 | Bulletin boards | r8.1 | Use bulletin board in town block |
| | | | | | | r8.2 | Use interchange column of the newspaper, magazine |
| | | | | | | r8.3 | Use telephone to ask |
| | | | | | | r8.4 | Meet and ask |
| | | | | | | r8.5 | Do nothing |
| Share own information with public | ○ | | ○ | t9 | Personal websites | r9.1 | Use telephone |
| | | | | | | r9.2 | Letter |
| | | | | | | r9.3 | Meet and talk |
| | | | | | | r9.4 | Use bulletin board in town block |
| | | | | | | r9.5 | Do nothing |
| Share own opinion with public | ○ | | | t10 | Blogs | r10.1 | Use telephone |
| | | | | | | r10.2 | Letter |
| | | | | | | r10.3 | Meet and talk |
| | | | | | | r10.4 | Use bulletin board in town block |
| | | | | | | r10.5 | Do nothing |
| Exchange information with colleague | ○ | | ○ | t11 | Social network service (SNS) | r11.1 | Use telephone |
| | | | | | | r11.2 | Letter |
| | | | | | | r11.3 | Meet and talk |
| | | | | | | r11.4 | Use bulletin board in town block |
| | | | | | | r11.5 | Do nothing |
| Watch paid video | ○ | | ○ | t12 | Paid video | r12.1 | Watch TV |
| | | | | | | r12.2 | Purchase digital versatile disc (DVD) |
| | | | | | | r12.3 | Rent DVD |
| | | | | | | r12.4 | Do nothing |
| Watch free video | ○ | | ○ | t13 | Free video | r13.1 | Watch TV |
| | | | | | | r13.2 | Do nothing |

**Table 1-1 – Target and reference scenarios**

| Function | Mobile network | | Broadband NW | Target scenario | | Reference scenario | |
|---|---|---|---|---|---|---|---|
| | 4G LTE | 3G W-CDMA | | ID | | ID | |
| Obtain information on food, drink, shopping, etc. | ○ | | ○ | t14 | Dining information | r14.1 | Look through yellow pages |
| | | | | | | r14.2 | Read books, magazines |
| | | | | | | r14.3 | Watch TV, Listen to radio |
| | | | | | | r14.4 | Read newspaper |
| | | | | | | r14.5 | Do nothing |
| Read books and magazines | ○ | | ○ | t15 | Digital books | r15.1 | Purchase books, magazines |
| | | | | | | r15.2 | Borrow books from library |
| | | | | | | r15.3 | Use internet cafe |
| | | | | | | r15.4 | Do nothing |
| Check communication fees | ○ | ○ | | t16 | Call carrier sites | r16.1 | Do nothing |
| Obtain terminal information | ○ | | | t17 | Call phone manu-facturer sites | r17.1 | Do nothing |
| Obtain route guidance | ○ | ○ | ○ | t18 | Map | r18.1 | Ask someone |
| | | | | | | r18.2 | Purchase map (paper) |
| | | | | | | r18.3 | Do nothing |
| Obtain traffic information and train/bus schedules | ○ | ○ | ○ | t19 | Transportation information and time schedules | r19.1 | Use train/bus schedules (paper) |
| | | | | | | r19.2 | Call and ask station |
| | | | | | | r19.3 | Do nothing |
| Read and watch general news | ○ | ○ | ○ | t20 | General news | r20.1 | Watch TV, Listen to radio |
| | | | | | | r20.2 | Read newspaper |
| | | | | | | r20.3 | Read magazines |
| | | | | | | r20.4 | Ask a person |
| | | | | | | r20.5 | Do nothing |
| Obtain weather information | ○ | ○ | ○ | t21 | Weather reports | r21.1 | Watch TV, Listen to radio |
| | | | | | | r21.2 | Read newspaper |
| | | | | | | r21.3 | Use weather forecasting telephone service |
| | | | | | | r21.4 | Do nothing |

**Table 1-1 – Target and reference scenarios**

| Function | Mobile network | | Broadband NW | Target scenario | | Reference scenario | |
|---|---|---|---|---|---|---|---|
| | 4G LTE | 3G W-CDMA | | ID | | ID | |
| Use banking service | ○ | | ○ | t22 | Online banking | r22.1 | Go to bank |
| | | | | | | r22.2 | Use automated teller machine (ATM) nearby |
| | | | | | | r22.3 | Use telephone banking service |
| | | | | | | r22.4 | Do nothing |
| Purchase books and magazines | ○ | | ○ | t23.1 | Online shopping (books, magazines) | r23.1 | Purchase in shop |
| | | | | | | r23.2 | Order on telephone |
| | | | | | | r23.3 | Order by postcard |
| | | | | | | r23.4 | Do nothing |
| Purchase CD and DVD | ○ | | ○ | t23.2 | Online shopping (CD, DVD) | r23.5 | Purchase in a shop |
| | | | | | | r23.6 | Order on telephone |
| | | | | | | r23.7 | Order by postcard |
| | | | | | | r23.8 | Do nothing |
| Purchase food, liquor, and drinks | ○ | | ○ | t23.3 | Online shopping (food, liquor, drinks) | r23.9 | Purchase in shop |
| | | | | | | r23.10 | Media shopping on TV, radio |
| | | | | | | r23.11 | Mail order with catalogues |
| | | | | | | r23.12 | Home delivery service |
| | | | | | | r23.13 | Do nothing |
| Purchase clothes and accessories | ○ | | ○ | t23.4 | Online shopping (clothes, accessories) | r23.14 | Purchase in shop |
| | | | | | | r23.15 | Media shopping on TV, radio |
| | | | | | | r23.16 | Mail order with catalogues |
| | | | | | | r23.17 | Do nothing |
| Buy and sell used goods | ○ | | ○ | t24 | Auctions | r24.1 | Free market, bazaar |
| | | | | | | r24.2 | Recycle shop |
| | | | | | | r24.3 | Personal trading |
| | | | | | | r24.4 | Do nothing |
| Apply for prize | ○ | | ○ | t25 | Awards, questionnaires | r25.1 | Postcard |
| | | | | | | r25.2 | Telephone |
| | | | | | | r25.3 | Do nothing |
| Obtain discount coupon | ○ | | ○ | t26 | Bargains, discount coupons | r26.1 | Leaflet |
| | | | | | | r26.2 | Direct mail |
| | | | | | | r26.3 | Information magazine, free newspaper |
| | | | | | | r26.4 | Do nothing |

**Table 1-1 – Target and reference scenarios**

| Function | Mobile network | | Broadband NW | Target scenario | | Reference scenario | |
|---|---|---|---|---|---|---|---|
| | 4G LTE | 3G W-CDMA | | ID | | ID | |
| Obtain stock market information | ○ | | ○ | t27 | Stocks, market information | r27.1 | Watch TV, Listen to radio |
| | | | | | | r27.2 | Read newspaper |
| | | | | | | r27.3 | Use electric bulletin board in street |
| | | | | | | r27.4 | Visit stock company |
| | | | | | | r27.5 | Call and ask stock company |
| | | | | | | r27.6 | Do nothing |
| Obtain miscellaneous information and culture | ○ | | ○ | t28 | Miscellaneous information and culture | r28.1 | Correspondence education |
| | | | | | | r28.2 | Go to school |
| | | | | | | r28.3 | Purchase books, magazines |
| | | | | | | r28.4 | Borrow books in a library |
| | | | | | | r28.5 | Do nothing |
| | | | | Number of target scenarios: 28 | | Number of reference scenarios: 121 | |

### 5.2.3 Functional unit

As described in clauses 5.1 and 5.2.2, the second order effects of each ICT service were evaluated by comparative analyses between target scenarios and corresponding reference scenarios, which were objectively set by using a customer questionnaire. Therefore, the functional unit was set as "completion of functions shown in Table 1-1 by a subscriber in a year".

### 5.2.4 System boundaries

To achieve the goal of this case study, each comparative analysis was carried out according to the following principles:

– GHG emissions were evaluated using the economic IO approach for the domestic part of raw material acquisition (RMA) and production. Due to restrictions on the IOA data used, non-domestic raw material and production activities were excluded. Furthermore, the results for RMA and production could not be separated.

The items considered and the life cycle stages evaluated in this case study are shown below.

Where they appear, the scenario IDs in subsequent tables correspond to those of Table 1-1.

**Table 1-2 – Mapping of checklist items on life cycle stages in comparative assessment: target scenario**

| Life cycle stage/category | Raw material acquisition and production | Use | End-of-life treatment (EoLT) | Items | Scenario ID |
|---|---|---|---|---|---|
| ICT hardware | ✓ | ✓ | ✓ | Smart phone | t1–t28 |
| | ✓ | ✓ | ✓ | Mobile phone | t1–t5,t7,t16,t18–t21 |
| | ✓ | ✓ | ✓ | PC | t1–t9,t11–t15,t18–t28 |
| | ✓ | ✓ | ✓ | 4G LTE NW | t1–t28 |
| | ✓ | ✓ | ✓ | 3G W-CDMA NW | t1–t5,t7,t16,t18–t21 |
| | ✓ | ✓ | ✓ | Broadband NW | t1–t9,t11–t15,t18–t28 |
| ICT software | * | * | * | * | |
| Consumables and other supportive products | * | * | * | * | |
| Site infrastructure | ✓ | ✓ | ✓ | Data centre | t3–t28 |
| Transport (movement of goods) | * | * | * | * | |
| Travel (movement of people) | * | * | * | * | |
| Storage of goods | * | * | * | * | |
| Working environment | * | * | * | * | |
| * Common building blocks not considered in comparative assessment. | | | | | |

**Table 1-3 – Mapping of checklist items on life cycle stages in comparative assessment: reference scenario**

| Life cycle stage/category | Raw material acquisition and production | Use | EoLT | Items | Scenario ID |
|---|:---:|:---:|:---:|---|---|
| ICT hardware | ✓ | ✓ | ✓ | Telephone | r1.1, r1.2, r2.1, r2.2, r7.4, r8.1, r8.3, r9.1, r10.1, r11.1, r19.2, r21.3, r22.3, r23.2, r23.6, r23.10, r23.15, r25.2, r27.5 |
| | ✓ | ✓ | ✓ | Fax | r2.4 |
| | ✓ | ✓ | ✓ | Server | r21.3, r22.3 |
| | ✓ | ✓ | ✓ | Player (music, video, game) | r3.1, r3.2, r5.1, r5.2, r12.2, r12.3 |
| | ✓ | ✓ | ✓ | Game machine Electric bulletin board | r5.3, r27.3 |
| | ✓ | ✓ | ✓ | Automated teller machine (ATM) | r22.2 |
| | ✓ | ✓ | ✓ | Television | r3.3, r6.1, r12.1, r13.1, r14.3, r20.1, r21.1, r23.10, r23.15, r27.1 |
| | ✓ | ✓ | ✓ | Public switched telephone network (PSTN) | r1.1, r1.2, r2.1, r2.2, r2.4, r7.4, r8.1, r8.3, r9.1, r10.1, r11.1, r19.2, r21.3, r22.3, r23.2, r23.6, r23.10, r23.15, r25.2, r27.5 |
| ICT software | * | * | * | * | |
| Consumables and other supportive products | ✓ | * | ✓ | Paper (letter, postcard, newspaper, book, magazine, poster, map, catalogue, free newspaper, leaflet etc.) | r2.3, r2.4, r6.2, r6.3, r6.4, r7.1, r7.2, r7.3, r8.1, r8.2, r9.2, r9.4, r10.2, r10.4, r11.2, r11.4, r14.1, r14.2, r14.4, r15.1, r15.2, r15.3, r18.2, r19.1, r20.2, r20.3, r21.2, r23.3, r23.7, r23.11, r23.12, r23.16, r25.1, r26.1, r26.2, r26.3, r27.2, r28.1, r28.3, r28.4 |
| | ✓ | * | ✓ | Recording media (CD, DVD, etc.) | r3.1, r3.2, r5.1, r5.2, r12.2, r12.3 |

**Table 1-3 – Mapping of checklist items on life cycle stages in comparative assessment: reference scenario**

| Life cycle stage/category | Raw material acquisition and production | Use | EoLT | Items | Scenario ID |
|---|---|---|---|---|---|
| Site infrastructure | ✓ | * | ✓ | Bulletin board | r8.1, r9.4, r10.4, r11.4 |
| | ✓ | * | ✓ | Mailbox | r2.3, r8.2, r9.2, r10.2, r11.2, r23.3, r23.7, r23.11, r23.16, r25.1, r28.1 |
| Transport (movement of goods) | ✓ | ✓ | ✓ | Mail Newspaper delivery | r2.3, r6.3, r8.2, r9.2, r10.2, r11.2, r14.4, r20.2, r21.2, r23.3, r23.7, r23.11, r23.16, r25.1, r26.1, r26.2, r27.2, r28.1 |
| Travel (movement of people) | ✓ | ✓ | ✓ | Movement for visit/purchase/rental, etc. | r1.3, r2.3, r2.5, r3.1, r3.2, r5.1, r5.2, r5.3, r6.2, r7.1, r7.3, r7.5, r8.1, r8.2, r8.4, r9.2, r9.3, r9.4, r10.2, r10.3, r10.4, r11.2, r11.3, r11.4, r12.2, r12.3, r14.2, r15.1, r15.2, r15.3, r18.2, r19.1, r20.3, r22.1, r22.2, r23.1, r23.3, r23.5, r23.7, r23.9, r23.11, r23.14, r23.16, r24.1, r24.2, r24.3, r25.1, r26.3, r27.3, r27.4, r28.1, r28.2, r28.3, r28.4 |
| Storage of goods | * | * | * | * | |
| Working environment | * | * | * | * | |
| * Common building blocks not considered in comparative assessment. | | | | | |

### 5.2.5 Cut-off

The study made the following cut-offs:

−   The Japanese IO data are based on domestic activities only. For this reason, all non-domestic activities related to RMA and production were cut-off. However, this cut-off is only partial as imports and exports are considered in the IO data to some extent. Due to lack of data, the impact from this cut-off could not be estimated.

−   The final transportation of ICT goods used in each scenario, such as smart phone, TV and servers in data centres, were cut-off.

### 5.2.6 Operating lifetime

This study assumes that each piece of equipment is used during its useful life in Japan, i.e. its depreciation time defined as the time during which a (new) revenue-generating asset reaches its residual economic value (sometimes referred to as its "legal lifetime") [b-Life, 2016], with some exceptions. The useful lifetimes and sources are shown in Table 1-4.

**Table 1-4 – Useful lifetime used in this case study: target scenario**

| Item | Useful lifetime [year] | Source | Scenario ID |
|---|---|---|---|
| Smart phone | 3.2 | Cabinet Office, Government of Japan [b-Consumer goods, 2016] | t1–t28 |
| Mobile phone | 3.2 | Cabinet Office, Government of Japan [b-Consumer goods, 2016] | t1–t5,t7,t16,t18–t21 |
| PC | 4 | Statutory useful lifetime in Japan [b-Life, 2016] | t1–t9,t11–t15,t18–t28 |
| 4G LTE NW | Depends on each piece of NW equipment Examples: server, 5 year; switch, 10 years; radio base station (RBS), *n* years | Field survey, Statutory useful lifetime in Japan [b-Life, 2016] | t1–t28 |
| 3G W-CDMA NW | Depends on each piece of NW equipment Examples: server, 5 years; switch, 10 years; RBS, *n* years | Field survey, Statutory useful lifetime in Japan [b-Life, 2016] | t1–t5,t7,t16,t18–t21 |
| Broadband NW | Depends on each piece of NW equipment Examples: server, 5 years; switch, 10 years | Field survey, Statutory useful lifetime in Japan [b-Life, 2016] | t1–t9,t11–t15,t18–t28 |
| Data centre equipment | Depends on each piece equipment Examples: Server, 5 years; switch, 10 years | Field survey, Statutory useful lifetime in Japan [b-Life, 2016] | t3–t28 |

**Table 1-5 – Useful lifetime used in this case study: reference scenario**

| Item | Useful lifetime [year] | Source | Scenario ID |
|---|---|---|---|
| Telephone | 7 | Statutory useful lifetime in Japan [b-Life, 2016] | r1.1, r1.2, r2.1, r2.2, r7.4, r8.1, r8.3, r9.1, r10.1, r11.1, r19.2, r21.3, r22.3, r23.2, r23.6, r23.10, r23.15, r25.2, r27.5 |
| Fax | 7 | | r2.4 |
| Server | 5 | | r21.3, r22.3 |
| Game machine Electric bulletin board | 4 | | r5.3, r27.3 |
| ATM | 5 | | r22.2 |
| Television | 5 | | r3.3, r6.1, r12.1, r13.1, r14.3, r20.1, r21.1, r23.10, r23.15, r27.1 |
| Paper (letter, postcard, newspaper, book, magazine, poster, map, catalogue, free newspaper, leaflet, etc.) | 1 | | r2.3, r2.4, r6.2, r6.3, r6.4, r7.1, r7.2, r7.3, r8.1, r8.2, r9.2, r9.4, r10.2, r10.4, r11.2, r11.4, r14.1, r14.2, r14.4, r15.1, r15.2, r15.3, r18.2, r19.1, r20.2, r20.3, r21.2, r23.3, r23.7, r23.11, r23.12, r23.16, r25.1, r26.1, r26.2, r26.3, r27.2, r28.1, r28.3, r28.4 |
| Recording media (CD, DVD, etc.) | 1 | | r3.1, r3.2, r5.1, r5.2, r12.2, r12.3 |
| Bulletin board | 10 | | r8.1, r9.4, r10.4, r11.4 |
| Mailbox | 45 | | r2.3, r8.2, r9.2, r10.2, r11.2, r23.3, r23.7, r23.11, r23.16, r25.1, r28.1 |
| Player (music, video) | 5 | | r3.1, r3.2, r12.2, r12.3 |
| Player (game) | 3.2 | Cabinet Office, Government of Japan [b-Consumer goods, 2016] | r5.1, r5.2, |
| PSTN equipment | Depends on each piece of NW equipment Examples: Server, 5 years; switch, 10 years | Field survey, Statutory useful lifetime in Japan [b-Life, 2016] | r1.1, r1.2, r2.1, r2.2, r2.4, r7.4, r8.1, r8.3, r9.1, r10.1, r11.1, r19.2, r21.3, r22.3, r23.2, r23.6, r23.10, r23.15, r25.2, r27.5 |

## 6	Data collection

The collected data items for evaluating the GHG emissions of the target and reference scenarios are shown in Table 6-1 and Table 6-2, respectively. The GHG emissions of 4G LTE NW, 3G W-CDMA NW, broadband NW and data centres were calculated with the emissions factor per unit information. The GHG emissions of PSTN were calculated with the emissions factor per line.

**Table 6-1 – Data items acquired in this case study: target scenario**

| Necessary information | | Data items | Scenario ID |
|---|---|---|---|
| Category | Items | | |
| ICT hardware | Smartphone | *1: Share of users performing the function [%] <br> *2: Average use time per function and user [min/day] <br> *3: Carbon footprint (CFP) (process sum data) [b-CFP-1,2013] | t1–t28 |
| | Mobile phone | *1: Share of users performing the function [%] <br> *2: Average use time per function and user [min/day] <br> *5: Price, weight, power consumption | t1–t5,t7,t16,t18–t21 |
| | PC | *1: Share of users performing the function [%] <br> *2: Average use time per function and user [min/day] <br> *5: Price, weight, power consumption | t1–t9,t11–t15,t18–t28 |
| | 4G LTE NW | *1: Share of users performing the function [%] <br> *2: Average use time per function and user [min/day] <br> *5: Amount of data per function [MB/min] | t1–t28 |
| | 3G W-CDMA NW | *1: Share of users performing the function [%] <br> *5: Amount of data per function [MB/min] | t1–t5,t7,t16,t18–t21 |
| | Broadband NW | *1: Share of users performing the function [%] <br> *2: Average use time per function and user [min/day] <br> *5: Amount of data per function [MB/min] | t1–t9,t11–t15,t18–t28 |
| Site infrastructure | Data centre | *1: Share of users performing the function [%] <br> *2: Average use time per function and user [min/day] <br> *5: Amount of data per function [MB/min] | t3–t28 |
| NOTE – *1: Questionnaire; *2: Public data; *3: Product specification sheet; *4: Assumption; *5: Survey | | | |

**Table 6-2 – Data items acquired in this case study: reference scenario**

| Necessary information | | Data items | Scenario ID |
|---|---|---|---|
| **Category** | **Items** | | |
| ICT hardware | Telephone | *1: Share of users performing the function [%]<br>*2. Average use time per function and user [min/day]<br>*3: Price, weight, power consumption | r1.1, r1.2, r2.1, r2.2, r7.4, r8.1, r8.3, r9.1, r10.1, r11.1, r19.2, r21.3, r22.3, r23.2, r23.6, r23.10, r23.15, r25.2, r27.5 |
| | Fax | | r2.4 |
| | Server | | r21.3, r22.3 |
| | Payer (music, video, game) | | r3.1, r3.2, r5.1, r5.2, r12.2, r12.3 |
| | Game machine | | r5.3 |
| | Electric bulletin board | | r27.3 |
| | Television | | r22.2 |
| | ATM | *1: Share of users performing the function [%]<br>*2: Average use time per function and user [min/day]<br>*3: CFP (process sum data) [b-CFP-1, 2013] | r22.2 |
| | PSTN | *1: Share of users performing the function [%]<br>*2: Average use time per function and user [min/day] | r3.3, r6.1, r12.1, r13.1, r14.3, r20.1, r21.1, r23.10, r23.15, r27.1 |
| Consumables and other supportive products | Paper | *1: Share of users performing the function [%]<br> average use frequency [times/day]<br>*4: Average number of paper sheets used [sheet/times] | r2.3, r2.4, r6.2, r6.3, r6.4, r7.1, r7.2, r7.3, r8.1, r8.2, r9.2, r9.4, r10.2, r10.4, r11.2, r11.4, r14.1, r14.2, r14.4, r15.1, r15.2, r15.3, r18.2, r19.1, r20.2, r20.3, r21.2, r23.3, r23.7, r23.11, r23.12, r23.16, r25.1, r26.1, r26.2, r26.3, r27.2, r28.1, r28.3, r28.4 |
| | Recording media | *1: Share of users performing the function [%]<br>average use frequency [times/day]<br>*4: Average use number of media used[media/times] | r3.1, r3.2, r5.1, r5.2, r12.2, r12.3 |

**Table 6-2 – Data items acquired in this case study: reference scenario**

| Necessary information | | Data items | Scenario ID |
|---|---|---|---|
| **Category** | **Items** | | |
| Site infrastructure | Bulletin board | *1: Share of users performing the function [%]<br>average use frequency [times/day]<br>*4: Average number of paper sheets used[sheet/times] | r8.1, r9.4, r10.4, r11.4 |
| | Mailbox | *1: Share of users performing the function [%]<br>average use frequency [times/day]<br>*4: Average number of letter sheets used [sheets/times] | r2.3, r8.2, r9.2, r10.2, r11.2, r23.3, r23.7, r23.11, r23.16, r25.1, r28.1 |
| Travel (movement of goods) | Mail<br>Newspaper delivery | *1: Share of users performing the function [%]<br>average use frequency [times/day],<br>average pages of newspaper used [pages] | r2.3, r6.3, r8.2, r9.2, r10.2, r11.2, r14.4, r20.2, r21.2, r23.3, r23.7, r23.11, r23.16, r25.1, r26.1, r26.2, r27.2, r28.1 |
| Travel (movement of people) | Movement for visit/purchase/renal, etc. | *1 Share of users performing the function [%]<br>average movement distance [km],<br>average pages of newspaper [page],<br>mode of transport (car, train, bus, motorbike, etc.) | r1.3, r2.3, r2.5, r3.1, r3.2, r5.1, r5.2, r5.3, r6.2, r7.1, r7.3, r7.5, r8.1, r8.2, r8.4, r9.2, r9.3, r9.4, r10.2, r10.3, r10.4, r11.2, r11.3, r11.4, r12.2, r12.3, r14.2, r15.1, r15.2, r15.3, r18.2, r19.1, r20.3, r22.1, r22.2, r23.1, r23.3, r23.5, r23.7, r23.9, r23.11, r23.14, r23.16, r24.1, r24.2, r24.3, r25.1, r26.3, r27.3, r27.4, r28.1, r28.2, r28.3, r28.4 |
| NOTE – *1: Questionnaire; *2: Public data; *3: Product specification sheet; *4: Assumption; *5: Survey | | | |

## 7 Data calculation

The data calculation was conducted on the basis of the conditions required by [ISO 14040], [ISO 14044] and [ITU-T L.1410].

[ITU-T L.1410] requires the calculation of seven types of GHGs, but only $CO_2$ emissions were calculated in this study, mainly because of the difficulty in acquiring adequate high quality data.

The calculation equations for GHG emissions ($CO_2$ emissions only in this study) and the collected data are shown in Table 7-1.

The GHG emissions of the mobile network, data centres and PSTN were calculated with corresponding emission factors per amount of data, in megabytes.

As shown in Table 7-1, for each included life cycle stage, the impact was calculated using the environmentally extended IOA emissions factors, defined per amount of data, kilowatt hours or similar. These emission factors were then recalculated to emission factors per equipment and use stage, using the previously described usage information. As an example, the RMA and production for the mobile network used an emission factor per megabyte, which was multiplied by the usage, by considering use frequency, time of use, percentage of users performing the activity and information content per activity.

The $CO_2$ emission values calculated per equipment were recalculated to reflect the number of users per device while assuming one user per smart phone and mobile phone, and 2.3 users per fixed line. This was implemented by multiplication by a factor of $N$ (number of user per line) to obtain the $CO_2$ emission per each ICT service usage.

**Table 7-1 – How to calculate GHG emissions from collected data**

| Category | How to calculate CO$_2$ emissions | Collected data and sources | Scenario ID | |
|---|---|---|---|---|
| | | | **Target** | **Reference** |
| | Mobile network (4G LTE, 3G W-CDMA) | | | |
| **ICT hardware** | <Raw material acquisition and production><br>$\Sigma$\{use frequency [time/day](\*1) $\times$ time of use [min/time](\*1) $\times$ user ratio [%](\*1) $\times$ information [MB/min](\*2) $\times$ 365 [days/year] $\times$ emission factor [g-CO$_2$/(year $\times$ MB)](\*3) $\div$ 1000\} | *1: Questionnaire<br>*2: Public data<br>*3: Survey | t1–t28 | – |
| | <Use><br>$\Sigma$\{use frequency [time/day](\*1) $\times$ time of use [min/time](\*1) $\times$ user ratio [%](\*1) $\times$ information [MB/min](\*2) $\times$ 365 [days/year] $\times$ emission factor [g-CO$_2$/(year $\times$ MB)](\*3) $\div$ 1000\} | | | |
| | <End-of-life treatment><br>$\Sigma$\{use frequency [time/day](\*1) $\times$ time of use [min/time](\*1) $\times$ user ratio [%](\*1) $\times$ information [MB/min](\*2) $\times$ 365 [days/year] $\times$ emission factor [g-CO$_2$/(year $\times$ MB)](\*3) $\div$ 1000\} | | | |
| | Broadband NW | | | |
| | <Raw material acquisition and production><br>$\Sigma$\{use frequency [time/day](\*1) $\times$ time of use [min/time](\*1) $\times$ user ratio [%](\*1) $\times$ information [MB/min](\*2) $\times$ 365 [days/year] $\times$ emission factor [g-CO$_2$/(year $\times$ MB)](\*3) $\div$ 1000\} | *1: Questionnaire<br>*2: Public data<br>*3: Survey | t1–t9,t11–t15,t18–t28 | – |
| | <Use><br>$\Sigma$\{use frequency [time/day](\*1) $\times$ time of use [min/time](\*1) $\times$ user ratio [%](\*1) $\times$ information [MB/min](\*2) $\times$ 365 [days/year] $\times$ emission factor [g-CO$_2$/(year $\times$ MB)](\*3) $\div$ 1000\} | | | |
| | <End-of-life treatment> | | | |

**Table 7-1 – How to calculate GHG emissions from collected data**

| Category | How to calculate CO₂ emissions | Collected data and sources | Scenario ID Target | Scenario ID Reference |
|---|---|---|---|---|
| | $\Sigma$\{use frequency [time/day](*1) $\times$ time of use [min/time](*1) $\times$ user ratio [%](*1) $\times$ information [MB/min](*2) $\times$ 365 [days/year] $\times$ emission factor [g-CO₂/(year $\times$ MB)](*3) $\div$ 1000\} | | | |
| | PSTN (public switched telephone network) | | | |
| | <Raw material acquisition and production> $\Sigma$\{time of use [min/day](*1) $\div$ 60 [min/hour] $\times$ user ratio [%](*1) $\times$ 365 [days/year] $\times$ emission factor [kg-CO₂/ line](*2) $\div$ total use time [hour/year](*3)\} | *1: Questionnaire *2: Survey *3: Public data *4: Emissions factor of electric power (source: [b-FEPC, 2016]) | – | r3.3, r6.1, r12.1, r13.1, r14.3, r20.1, r21.1, r23.10, r23.15, r27.1 |
| | <Use> $\Sigma$\{power consumption [kW](*3) $\times$ time of use [min/day](*1) $\div$ 60 [min/hour] $\times$ user ratio [%](*1) $\times$ 365 [days/year] $\times$ emission factor [kg-CO₂/kWh](*4)\} | | | |
| | <End-of-life treatment> $\Sigma$\{time of use [min/day](*1) $\div$60 [min/hour] $\times$ user ratio [%](*1) $\times$ 365 [days/year] $\times$ emission factor [kg-CO₂/line](*2) $\div$ total use time [hour/year](*3)\} | | | |
| | Smartphone | | | |
| | <Raw material acquisition and production> $\Sigma$\{time of use [min/day](*1) $\div$60 [min/hour] $\times$ user ratio [%](*1) $\times$ 365 [days/year] $\times$ Emission factor [kg-CO₂/unit](*2) $\div$ lifetime [year](*3) $\div$ total use time [hour/year](*1)\} | *1: Questionnaire *2: Emission factor (source: [b-CFP-1, 2013]) *3: Cabinet Office, Government of Japan [b-Consumer goods, 2016] | t1–t28 | – |
| | <Use> $\Sigma$\{power consumption [kW](*1) $\times$ annual operating time of hardware [hour/year](*2) $\times$ emission factor [kg-CO₂/kWh](*3)\} | *1: Power consumption (source: product specification sheet) *2: Questionnaire | | |

**Table 7-1 – How to calculate GHG emissions from collected data**

| Category | How to calculate CO₂ emissions | Collected data and sources | Scenario ID Target | Scenario ID Reference |
|---|---|---|---|---|
| | | *3: Emissions factor of electric power (source: [b-FEPC, 2016]) | | |
| | <End-of-life treatment><br>$\Sigma$\{time of use [min/day](*1) ÷60 [min/hour] × user ratio [%](*1) × 365 [days/year] × Emission factor [kg-CO₂/ unit](*2) ÷ lifetime[year](*3) ÷ total use time [hour/year](*1)\} | *1: Questionnaire<br>*2: Emission factor (source: [b-CFP-1, 2013])<br>*3: Cabinet Office, Government of Japan [b-Consumer goods, 2016] | | |
| | ATM | | | |
| | <Raw material acquisition and production><br>$\Sigma$\{time of use [min/day](*1) ÷60 [min/hour] × user ratio [%](*1) × 365 [days/year] × Emission factor [kg-CO₂/unit](*2) ÷ lifetime [year](*3) ÷ total use time [hour/year](*4)\} | *1: Questionnaire<br>*2: Emission factor (source: [b-CFP-2, 2013])<br>*3: Statutory useful life in Japan (source: Finance Ministry [b-Life, 2016])<br>*4: Assumption | | |
| | <Use><br>$\Sigma$\{power consumption [kW](*1) × annual operating time of hardware [hour/year](*2) × emission factor [kg-CO₂/kWh](*3)\} | *1: Power consumption (source: [b-CFP-2, 2013])<br>*2: Questionnaire<br>*3: Emissions factor of electric power (source: [b-FEPC, 2016]) | | |
| | <End-of-life treatment><br>$\Sigma$\{time of use [min/day](*1) ÷60 [min/hour] × user ratio [%](*1) × 365 [days/year] × Emission factor [kg-CO₂/ unit](*2) ÷ lifetime[year](*3) ÷ total use time [hour/year](*4)\} | *1: Questionnaire<br>*2: Emission factor (source: [b-CFP-2, 2013]<br>*3: Statutory useful life in Japan (source: Finance Ministry [b-Life, 2016])<br>*4: Assumption | | |
| | Mobile phone | | | |
| | <Raw material acquisition and production><br>$\Sigma$\{time of use [min/day](*4) ÷60 [min/hour] × user ratio [%](*4) × 365 [days/year] × Prices of hardware | *1: Survey<br>*2: Emissions factor of hardware for raw material acquisition and production and end-of-life treatment (source: [b-3EID, 2000]) | t1–t5, t16, t7, t18–t21 | – |

**Table 7-1 – How to calculate GHG emissions from collected data**

| Category | How to calculate $CO_2$ emissions | Collected data and sources | Scenario ID | |
|---|---|---|---|---|
| | | | **Target** | **Reference** |
| | [yen](*1) × emission factor [kg-$CO_2$/yen](*2) ÷ lifetime [year](*3) ÷ total use time [hour/year](*4)} | *3: Statutory useful life in Japan (source: Finance Ministry [b-Life, 2016])<br>*4: Questionnaire | | |
| | <Use><br>$\Sigma$\{power consumption [kW](*1) × annual operating time of hardware [hour/year](*2) × emission factor [kg-$CO_2$/kWh](*3)} | *1: Measurements of electric power consumption<br>*2: Questionnaire<br>*3: Emissions factor of electric power (source: [b-FEPC, 2016]) | | |
| | <End-of-life treatment><br>$\Sigma$\{time of use [min/day](*4) ÷60 [min/hour] × user ratio [%](*4) × 365 [days/year] × Weight of hardware [kg](*1) × emission factor [kg-$CO_2$/kg](*2) ÷ lifetime [year](*3) ÷ total use time [hour/year](*4)} | *1: Weight of the hardware (source: product specification sheet)<br>*2: Emission factor of waste disposal treatment (source: [b-3EID, 2000])<br>*3: Statutory useful life in Japan (source: Finance Ministry [b-Life, 2016])<br>*4: Questionnaire | | |
| | PC, telephone, fax, server, payer (music, video, game), game machine, electric bulletin board, television | | | |
| | <Raw material acquisition and production><br>$\Sigma$\{time of use [min/day](*4) ÷60 [min/hour] × user ratio [%](*4) × 365 [days/year] × Prices of hardware [yen](*1) × emission factor [kg-$CO_2$/yen](*2) ÷ lifetime [year](*3) ÷ total use time [hour/year](*4)} | *1: Prices of hardware (source: statistics of Japan Electronics and Information Technology Industries Association, 2014)<br>*2: Emissions factor of hardware for raw material acquisition and production and end-of-life treatment (source: [b-3EID, 2000])<br>*3: Statutory useful life in Japan (source: Finance Ministry [b-Life, 2016])<br>*4: Questionnaire | – | r1.1, r1.2, r2.1, r2.2, r2.4, r3.1, r3.2, r5.1, r5.2, r5.3, r7.4, r8.1, r8.3, r9.1, r10.1, r11.1, r12.2, r12.3, r19.2, r21.3, r22.2,r22.3, |
| | <Use><br>$\Sigma$\{power consumption [kW](*1) × annual operating time of hardware [hour/year](*2) × emission factor [kg-$CO_2$/kWh](*3)} | *1: Measurements of electric power consumption<br>*2: Questionnaire<br>*3: Emissions factor of electric power (source: [b-FEPC, 2016]) | | |

**Table 7-1 – How to calculate GHG emissions from collected data**

| Category | How to calculate $CO_2$ emissions | Collected data and sources | Scenario ID | |
|---|---|---|---|---|
| | | | **Target** | **Reference** |
| | <End-of-life treatment><br>$\Sigma$\{time of use [min/day](*4) $\div$60 [min/hour] $\times$ user ratio [%](*4) $\times$ 365 [days/year] $\times$ Weight of hardware [kg](*1) $\times$ emission factor [kg-$CO_2$/kg](*2) $\div$ lifetime [year](*3) $\div$ total use time [hour/year](*4)\} | *1: Weight of hardware (source: product specification sheet)<br>*2: Emission factor of waste disposal treatment (source: [b-3EID, 2000])<br>*3: Statutory useful life in Japan (source: Finance Ministry [b-Life, 2016])<br>*4: Questionnaire | | r23.2, r23.6, r23.10, r23.15, r25.2, r27.3, r27.5 |
| | Paper | | | |
| **Consumables and other supportive products** | <Raw material acquisition and production><br>$\Sigma$\{use frequency [time/year](*1) $\times$ number of sheets to use [sheet/time] (number of letters per email $\div$ number of letters per A4 size sheet)(*2) $\times$ user ratio [%](*1) $\times$ emission factor [kg-$CO_2$/sheet](*3)\} | *1: Questionnaire<br>*2: Public data<br>*3: Emision factor of paper (source: [b-JPA, 2007]) | – | r2.3, r2.4, r6.2, r6.3, r6.4, r7.1, r7.2, r7.3, r8.1, r8.2, r9.2, r9.4, r10.2, r10.4, r11.2, r11.4, r14.1, r14.2, r14.4, r15.1, r15.2, r15.3, r18.2, r19.1, r20.2, r20.3, r21.2, r23.3, |
| | <Use><br>Nothing | | | |
| | <End-of-life treatment><br>Nothing | | | |

**Table 7-1 – How to calculate GHG emissions from collected data**

| Category | How to calculate CO₂ emissions | Collected data and sources | Scenario ID | |
|---|---|---|---|---|
| | | | **Target** | **Reference** |
| | | | | r23.7, r23.11, r23.12, r23.16, r25.1, r26.1, r26.2, r26.3, r27.2, r28.1, r28.3, r28.4 |
| | Recording media (CD, DVD, game) | | | |
| | <Raw material acquisition and production> $\Sigma$\{use frequency[day/year](*1) $\times$ time of use [min/day](*1) $\div$ media capacity [min/media] (*2)\} $\times$ emission factor [kg-CO₂/media](*3) | *1: Questionnaire *2: Public data *3: Survey | – | r3.1, r3.2, r5.1, r5.2, r12.2, r12.3 |
| | <Use> $\Sigma$\{use frequency [day/year](*1) $\times$ time of use [min/day](*1) $\div$ media capacity [min/media](*2)\} $\times$ emission factor [kg-CO₂/media](*3) | | | |
| | <End-of-life treatment> $\Sigma$\{use frequency [day/year](*1) $\times$ time of use [min/day](*1) $\div$ media capacity [min/media](*2)\} $\times$ emission factor[kg-CO₂/media](*3) | | | |
| | Data centre | | | |
| **Site infrastructure** | <Raw material acquisition and production> $\Sigma$\{use frequency [time/day](*1) $\times$ time of use [min/time](*1) $\times$ user ratio [%](*1) $\times$ information | *1: Questionnaire *2: Survey | t3–t28 | – |

**Table 7-1 – How to calculate GHG emissions from collected data**

| Category | How to calculate CO₂ emissions | Collected data and sources | Scenario ID | |
| --- | --- | --- | --- | --- |
| | | | Target | Reference |
| | [MB/min](*2) × 365 [days/year]]/1000 × emission factor [g-CO₂/MB](*2)} | | | |
| | <Use><br>Σ{use frequency [time/day](*1) × time of use [min/time](*1) × user ratio [%](*1) × information [MB/min](*2) × 365 [days/year]]/1000 × emission factor[g-CO₂/MB](*2)} | | | |
| | <End-of-life treatment><br>Σ{use frequency [time/day](*1) × time of use [min/time](*1) × user ratio [%](*1) × information [MB/min](*2) × 365 [days/year]]/1000 × emission factor [g-CO₂/MB](*2)} | | | |
| | Bulletin board, mailbox | | | |
| | <Raw material acquisition and production><br>Σ{use frequency [time/year](*1) × number of sheets [sheet/time](*2) × emission factor [kg-CO₂/sheet](*3)} | *1: Questionnaire<br>*2: Public data<br>*3: Survey | | r2.3, r8.1, r8.2, r9.2, r9.4, r10.2, r10.4, r11.2, r11.4 r23.3, r23.7, r23.11, r23.16, r25.1, r28.1 |
| | <Use><br>Nothing | | | |
| | <End-of-life treatment><br>Σ{use frequency [day/year](*1) × number of sheets [sheet/day](*2) × emission factor [kg-CO₂/sheet](*3) | | | |
| **Transport** | Delivery | | | |
| | <Raw material acquisition and production> | *1: Questionnaire | | |

**Table 7-1 – How to calculate GHG emissions from collected data**

| Category | How to calculate CO$_2$ emissions | Collected data and sources | Scenario ID | |
|---|---|---|---|---|
| | | | **Target** | **Reference** |
| **(movement of goods)** | Σ{use frequency [day/year](*1) × number of sheets [sheet/day](*2) × emission factor [kg-CO$_2$/sheet](*3) | *2: Public data<br>*3: Survey | – | r2.3, r6.3, r8.2, r9.2, r10.2, r11.2, r14.4, r20.2, r21.2, r23.3, r23.7, r23.11, r23.16, r25.1, r26.1, r26.2, r27.2, r28.1 |
| | <Use><br>Σ{use frequency [day/year](*1) × number of sheets [sheet/day](*2) × emission factor [kg-CO$_2$/sheet](*3) | | | |
| | <End-of-life treatment><br>Σ{use frequency [day/year](*1) × number of sheets [sheet/day](*2) × emission factor [kg-CO$_2$/sheet](*3) | | | |
| **Transport (movement of people** | Travel (railway, bus, automobile, motorcycle) | | | |
| | <Raw material acquisition and production><br>Σ{use frequency [time/year](*1) × movement distance [person*km/time](*1) × emission factor [kg-CO$_2$/(person*km)](*2) | *1: Questionnaire<br>*2: Survey | – | r1.3, r2.3, r2.5, r3.1, r3.2, r5.1, r5.2, r5.3, r6.2, r7.1, r7.3, r7.5, r8.1, r8.2, r8.4, r9.2, r9.3, r9.4, r10.2, r10.3, r10.4, r11.2, r11.3, |
| | <Use><br>Σ{use frequency [time/year](*1) ×movement distance [person*km/time](*1) × emission factor [kg-CO$_2$/(person*km)](*2) | | | |
| | <End-of-life treatment><br>Σ{use frequency [time/year](*1) × movement distance [person*km/time](*1) × emission factor [kg-CO$_2$/(person*km)](*2) | | | |

**Table 7-1 – How to calculate GHG emissions from collected data**

| Category | How to calculate CO$_2$ emissions | Collected data and sources | Scenario ID | |
| --- | --- | --- | --- | --- |
| | | | **Target** | **Reference** |
| | | | | r11.4, r12.2, r12.3, r14.2, r15.1, r15.2, r15.3, r18.2, r19.1, r20.3, r22.1, r22.2, r23.1, r23.3, r23.5, r23.7, r23.9, r23.11, r23.14, r23.16, r24.1, r24.2, r24.3, r25.1, r26.3, r27.3, r27.4, r28.1, r28.2, r28.3, r28.4 |

NOTE – Σ means sum of each scenario.

LCA databases and public data used in this case study are shown in Table 7-2.

**Table 7-2 – LCA databases and public data used in this case study**

| | | Source | Reference |
|---|---|---|---|
| Emissions factor | Electric power | FEPC: The Federation of Electric Power Companies of Japan<br>$CO_2$ emissions intensity user end electricity averaged over 12 electric power companies, including distribution loss in the electricity supply chain for year 2013 | [b-FEPC, 2016] |
| | Hardware (mobile phone, PC, telephone, fax, etc.) for raw material acquisition and production and end-of-life treatment | 3EID: *Embodied energy and emission intensity data for Japan using input–output tables* | [b-3EID, 2000] |
| | Hardware (smart phone, ATM) for raw material acquisition and production and end-of-life treatment | CFP, Japan Environmental Management Association for Industry | [b-CFP-2, 2013] |
| Price of ICT equipment | Telephone, fax, server, payer (music, video, game), game machine, electric bulletin board, television | Catalogue,<br>field survey | [b-JEITA, 2010]<br>[b-JEITA, 2008] |

# 8 Results

The results for the assessed ICT services were combined for each of the three scenarios and are presented in this clause. As the reference for each scenario is the assumed use if the service had not been available, the different scenarios (LTE, W-CDMA and IP broadband) are compared to different baselines and the results for these scenarios cannot be directly compared.

## 8.1 4G LTE service

Figure 8-1 and Table 8-1 show the assessment results by function.

Functions such as "Voice call", "Email", "Search and link aggregation", "Bulletin board", "SNS", and "Online shopping" have large second order effects.
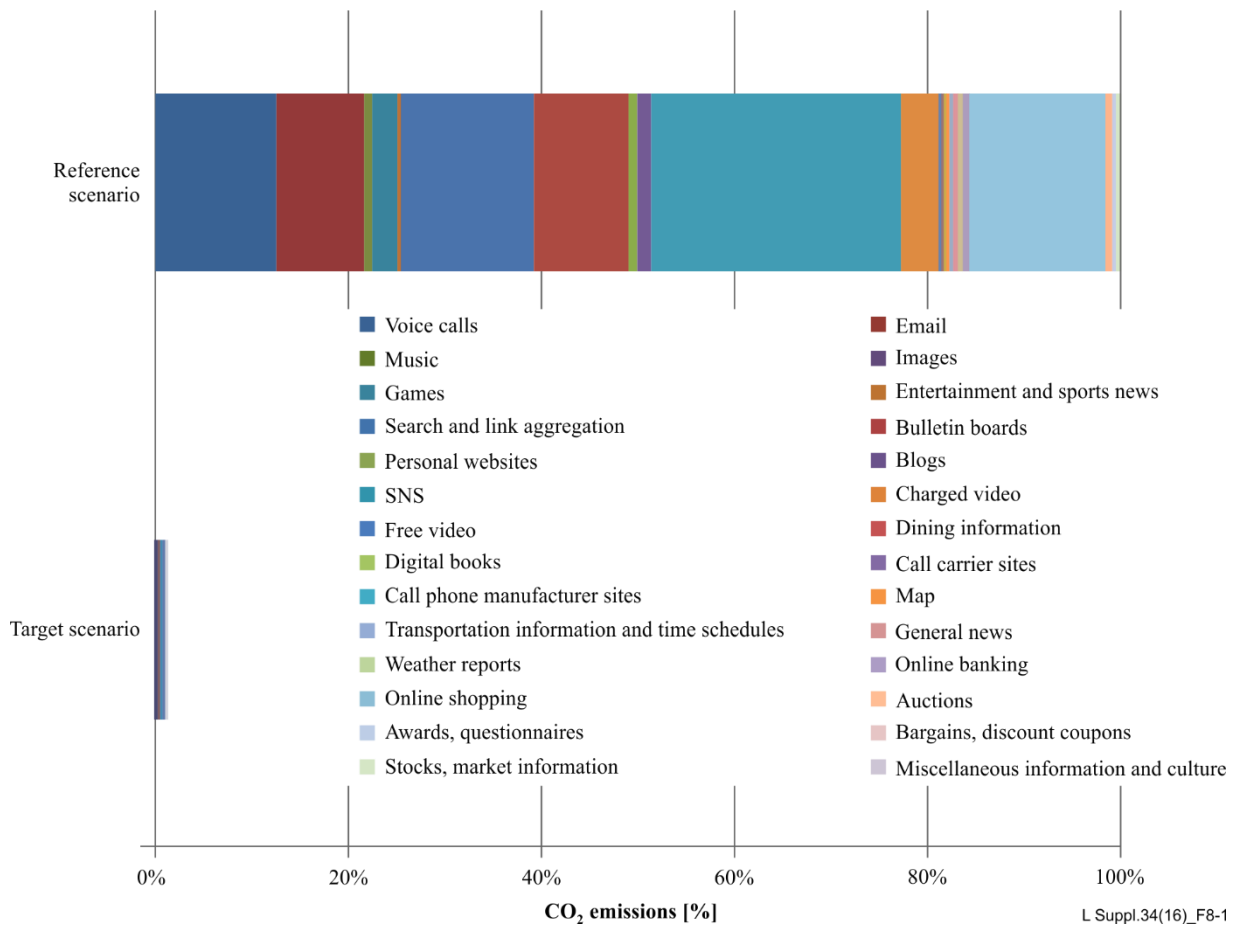


**Figure 8-1 – Assessment results by function (4G LTE service)**

NOTE – This LCA result cannot be compared with that of another LCA unless all assumptions and modelling choices are equal.

**Table 8-1 – Assessment results by scenarios (4G LTE)**

| Function | $CO_2$ emission [%] | |
|---|---|---|
| | **Target scenario** | **Reference scenario** |
| **Voice calls** | 0.2 | 13 |
| **Email** | 0.06 | 9 |
| **Music** | 0.05 | 0.9 |
| **Images** | 0.03 | 0 |
| **Games** | 0.05 | 2 |
| **Entertainment and sports news** | 0.04 | 0.4 |
| **Search and link aggregation** | 0.1 | 14 |
| **Bulletin boards** | 0.01 | 10 |
| **Personal websites** | 0.003 | 1 |
| **Blogs** | 0.004 | 1 |
| **SNS** | 0.07 | 26 |
| **Charged video** | 0.03 | 4 |
| **Free video** | 0.2 | 0.3 |
| **Dining information** | 0.006 | 0.2 |
| **Digital books** | 0.005 | 0.2 |
| **Call carrier sites** | 0.009 | 0 |
| **Call phone manufacture sites** | 0.003 | 0 |
| **Map** | 0.02 | 0.4 |
| **Transportation information and time schedules** | 0.01 | 0.5 |
| **General news** | 0.07 | 0.6 |
| **Weather reports** | 0.03 | 0.3 |
| **Online banking** | 0.002 | 0.9 |
| **Online shopping** | 0.01 | 14 |
| **Auctions** | 0.002 | 0.6 |
| **Awards, questionnaires** | 0.04 | 0.3 |
| **Bargains, discount coupons** | 0.005 | 0.2 |
| **Stocks, market information** | 0.004 | 0.6 |
| **Miscellaneous information and culture** | 0.001 | 0.2 |
| **Total** | 1.1 | 100 |

Figure 8-2 and Table 8-2 show assessment results by checklist item.

The main second order effect is "Travel (movement of people)".



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**Figure 8-2 – Assessment results by checklist items (4G LTE)**

NOTE – This LCA result cannot be compared with that of another LCA unless all assumptions and modelling choices are equal.

**Table 8-2 – Assessment results by checklist item (4G LTE)**

|  | ICT hardware | Consumables and other supportive products | Site infrastructure | Transport (movement of goods) | Travel (movement of people) | Total | Reduction amount |
|---|---|---|---|---|---|---|---|
|  | $CO_2$ emission [%] | | | | | | |
| **Reference scenario** | 7 | 3 | 0.04 | 0.2 | 90 | 100 | – |
| **Target scenario** | 0.9 | – | 0.1 | – | – | 1 | 99 |

Figure 8-3 and Table 8-3 show the results by life cycle stage.

The main second order effect is in the "Use" stage.
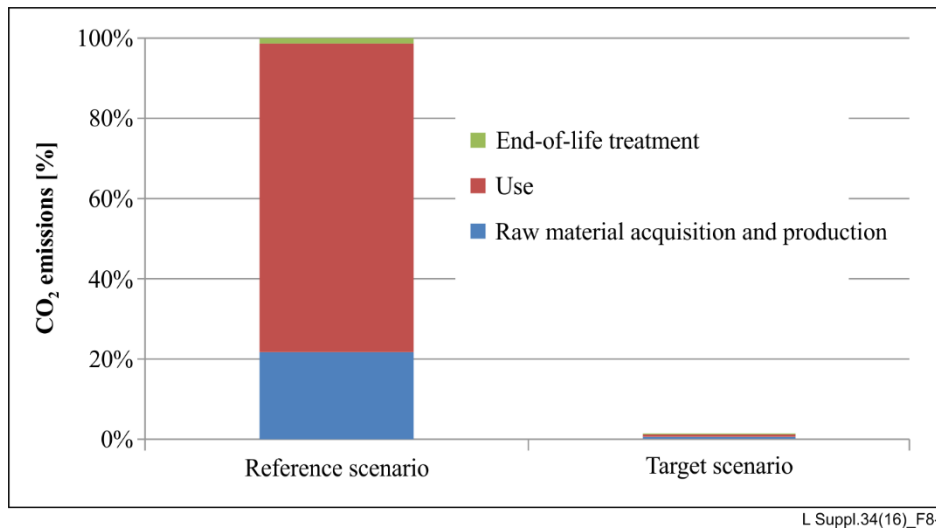
**Figure 8-3 – Assessment results by life cycle stage (4G LTE)**

NOTE – This LCA result cannot be compared with that of another LCA unless all assumptions and modelling choices are equal.

**Table 8-3 – Assessment results by life cycle stage (4G LTE)**

|  | Raw material acquisition and production | Use | End-of-life treatment | Total | Reduction amount |
|---|---|---|---|---|---|
|  | $CO_2$ emission [%] | | | | |
| **Reference scenario** | 21 | 77 | 1 | 100 | – |
| **Target scenario** | 0.5 | 0.6 | 0.001 | 1 | 99 |

## 8.2    3G W-CDMA service

Figure 8-4 and Table 8-4 show the assessment results by function.

Functions such as "Voice call", "Email", and "Search and link aggregation" have large second order effects.

**Figure 8-4 – Assessment results by function (3G W-CDMA)**

NOTE – This LCA result cannot be compared with that of another LCA unless all assumptions and modelling choices are equal.

**Table 8-4 – Assessment results by function (3G W-CDMA)**

| Function | $CO_2$ emission [%] | |
|:---:|:---:|:---:|
| | **Target scenario** | **Reference scenario** |
| **Voice calls** | 2 | 50 |
| **Email** | 1.3 | 31 |
| **Music** | 0.07 | 0.9 |
| **Images** | 0.04 | 0 |
| **Games** | 0.06 | 3 |
| **Search and link aggregation** | 0.2 | 13 |
| **Call carrier sites** | 0.1 | 0 |
| **Map** | 0.04 | 0.2 |
| **Transportation information and time schedules** | 0.04 | 0.6 |
| **General news** | 0.2 | 0.5 |
| **Weather reports** | 0.1 | 0.4 |
| **Total** | 4 | 100 |

Figure 8-5 and Table 8-5 show the assessment results by checklist item.

The main second order effect is "Travel (movement of people)".
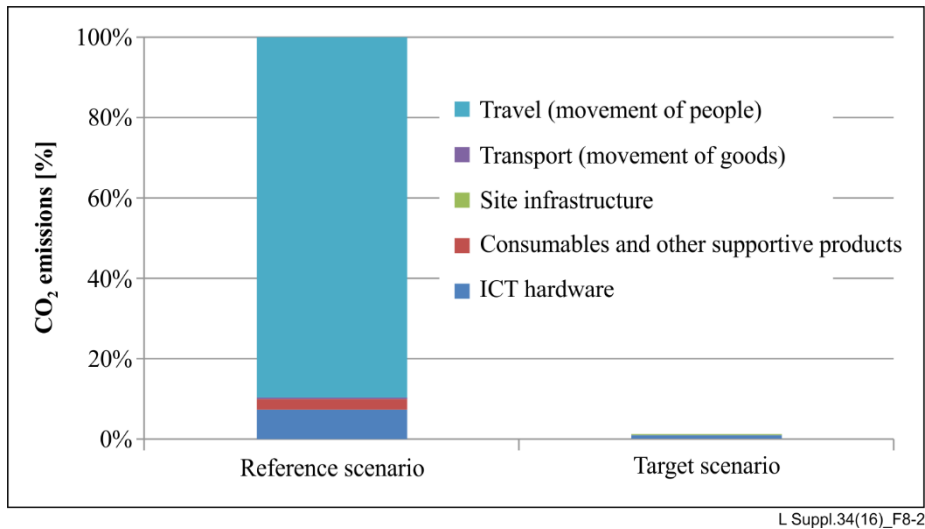


**Figure 8-5 – Assessment results by checklist item (3G W-CDMA)**

NOTE – This LCA result cannot be compared with that of another LCA unless all assumptions and modelling choices are equal.

**Table 8-5 – Assessment results by checklist item (3G W-CDMA)**

| | ICT hardware | Consumables and other supportive products | Site infrastructure | Transport (movement of goods) | Travel (movement of people) | Total | Reduction amount |
|---|---|---|---|---|---|---|---|
| | CO$_2$ emission [%] | | | | | | |
| **Reference scenario** | 22 | 2 | 0.02 | 0.1 | 76 | 100 | – |
| **Target scenario** | 4 | – | 0.07 | – | – | 4 | 96 |

Figure 8-6 and Table 8-6 show the results by checklist life cycle stage. The main second order effect is in the "Use" stage.
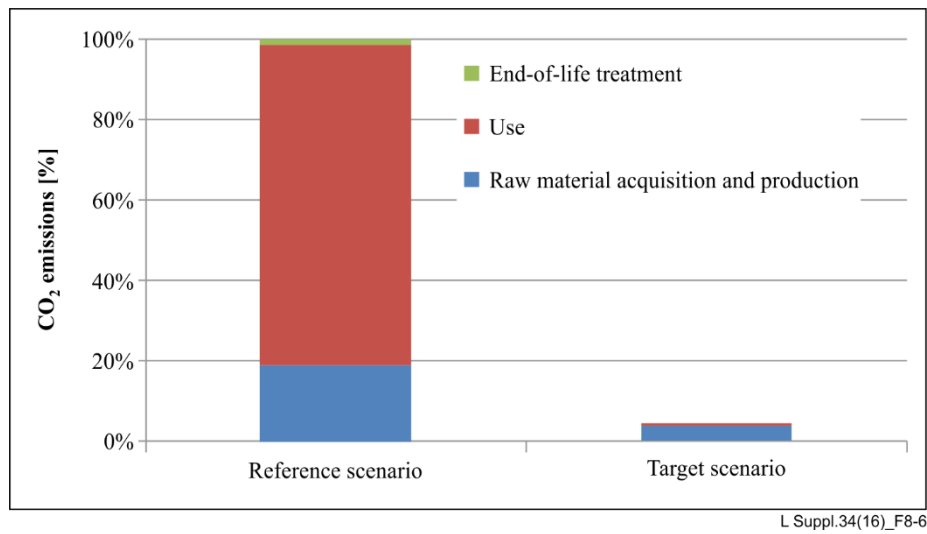


**Figure 8-6 – Assessment results by life cycle stage (3G W-CDMA)**

NOTE – This LCA result cannot be compared with that of another LCA unless all assumptions and modelling choices are equal.

**Table 8-6 – Assessment results by life cycle stage (3G W-CDMA)**

| | Raw material acquisition & Production | Use | End-of-life treatment | Total | Reduction amount |
|---|---|---|---|---|---|
| | $CO_2$ emission [%] | | | | |
| **Reference scenario** | 19 | 80 | 1 | 100 | – |
| **Target scenario** | 3 | 0.9 | –0.3 | 4 | 96 |

## 8.3 Broadband NW service

Figure 8-7 and Table 8-7 show the assessment results by function. Functions such as "Voice call", "Email", "Search and link aggregation", "Bulletin board", "SNS" and "Online shopping" have large second order effects.
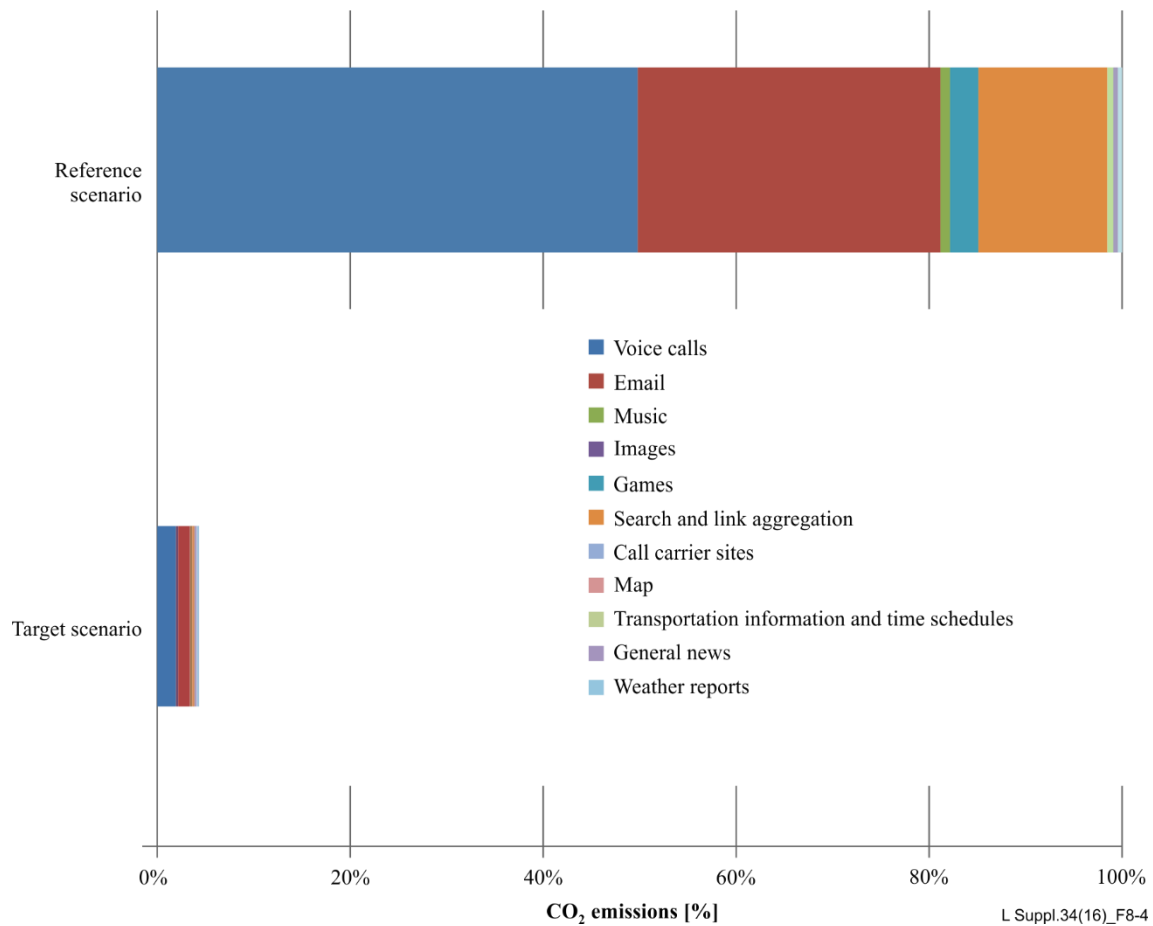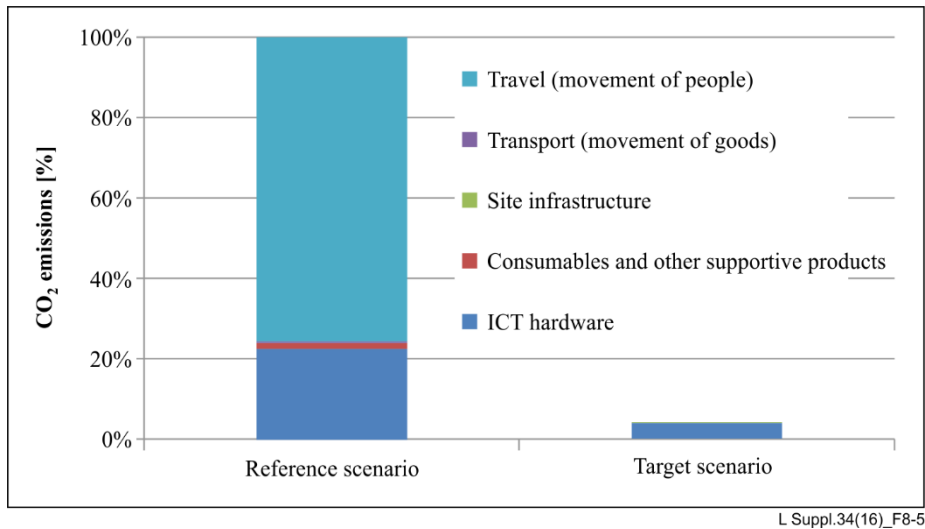
**Figure 8-7 – Assessment results by function (broadband NW)**

NOTE – This LCA result cannot be compared with that of another LCA unless all assumptions and modelling choices are equal.

**Table 8-7 – Assessment results by function (broadband NW)**

| Function | $CO_2$emission [%] | |
|---|---|---|
| | **Target scenario** | **Reference scenario** |
| **Voice calls** | 0.7 | 3 |
| **Email** | 0.4 | 6 |
| **Music** | 0.06 | 2 |
| **Images** | 0.06 | 0 |
| **Games** | 0.1 | 0.9 |
| **Entertainment and sports news** | 0.3 | 0.7 |
| **Search and link aggregation** | 1 | 13 |
| **Bulletin boards** | 0.06 | 8 |
| **Personal websites** | 0.05 | 3 |
| **SNS** | 0.09 | 15 |
| **Charged video** | 0.1 | 4 |
| **Free video** | 2 | 0.6 |
| **Dining information** | 0.06 | 0.6 |

**Table 8-7 – Assessment results by function (broadband NW)**

| Function | CO$_2$ emission [%] | |
|---|---|---|
| | **Target scenario** | **Reference scenario** |
| **Digital books** | 0.01 | 0.2 |
| **Map** | 0.1 | 1 |
| **Transportation information and time schedules** | 0.06 | 0.9 |
| **General news** | 0.5 | 1 |
| **Weather reports** | 0.2 | 0.4 |
| **Online banking** | 0.03 | 3 |
| **Online shopping** | 0. 1 | 33 |
| **Auctions** | 0.02 | 1 |
| **Awards, questionnaires** | 0.8 | 1 |
| **Bargains, discount coupons** | 0.03 | 0.2 |
| **Stocks, market information** | 0.08 | 1 |
| **Miscellaneous information and culture** | 0.03 | 0.5 |
| **Total** | 6 | 100 |

Figure 8-8 and Table 8-8 show the assessment results by checklist item.

The main second order effect is "Travel (movement of people)".
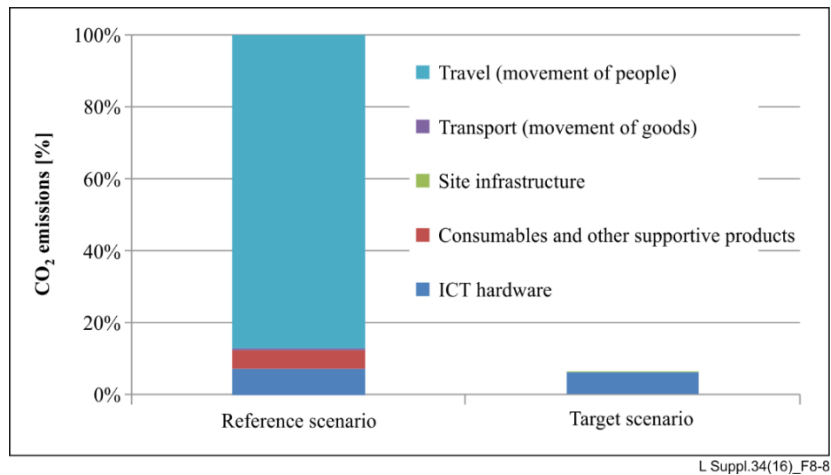


**Figure 8-8 – Assessment results by checklist item (broadband NW)**

NOTE – This LCA result cannot be compared with that of another LCA unless all assumptions and modelling choices are equal.

**Table 8-8 – Assessment results by checklist item (broadband NW)**

| | ICT hardware | Consumables and other supportive products | Site infrastructure | Transport (movement of goods) | Travel (movement of people) | Total | Reduction amount |
|---|---|---|---|---|---|---|---|
| | $CO_2$ emission [%] | | | | | | |
| **Reference scenario** | 7 | 5 | 0.0002 | 0.6 | 87 | 100 | – |
| **Target scenario** | 6 | – | 0.2 | – | – | 6 | 94 |

Figure 8-9 and Table 8-9 show the results by checklist life cycle stage.

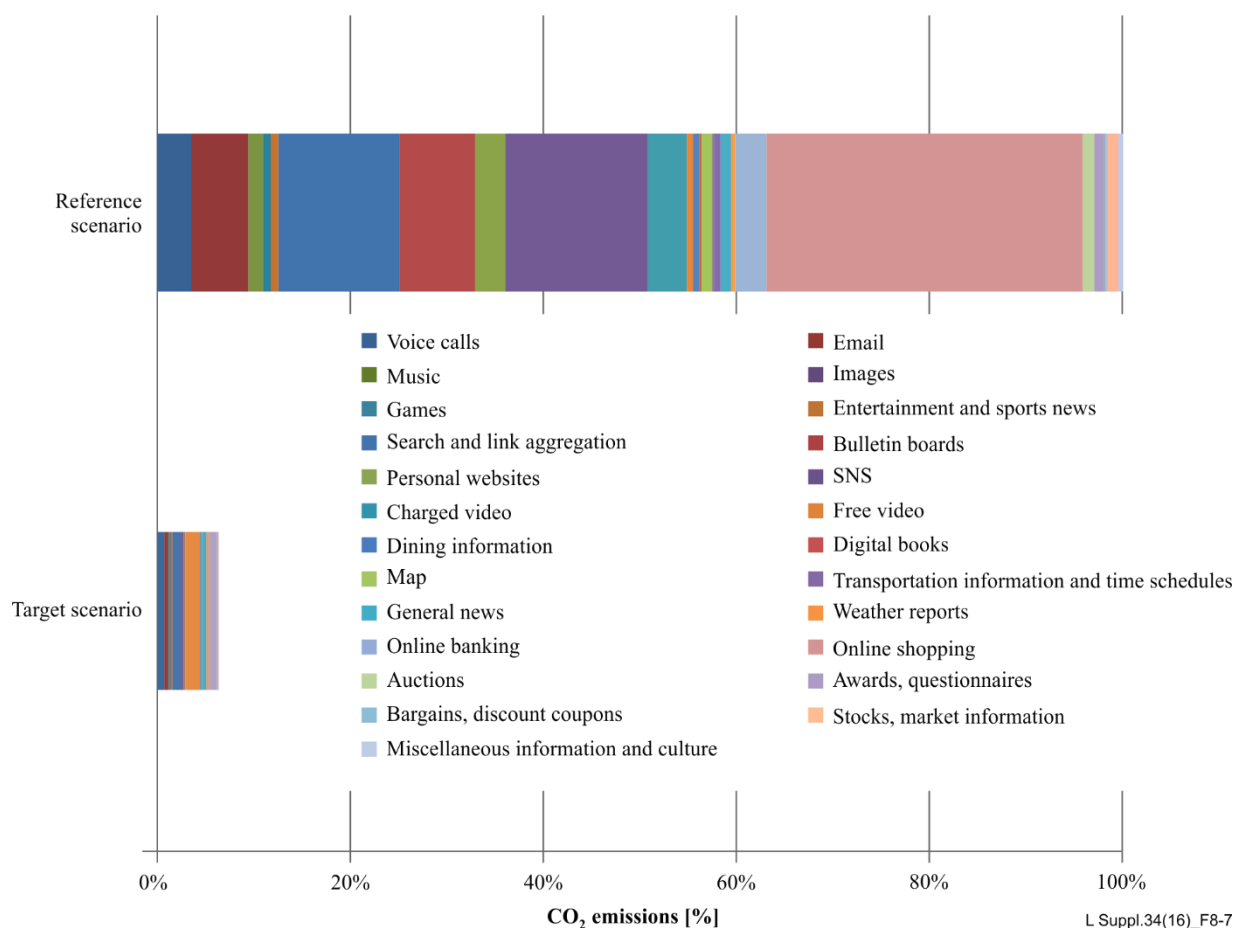The main second order effect is in the "Use" stage.
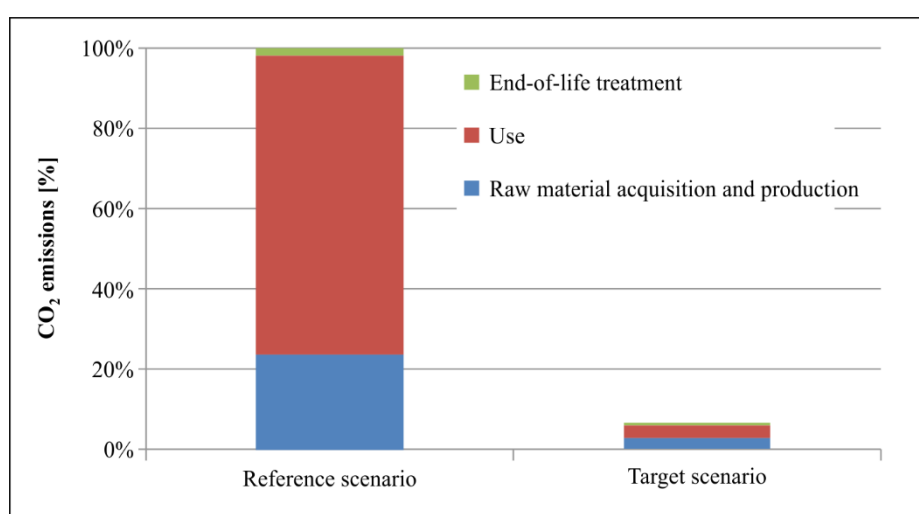


**Figure 8-9 – Assessment results by life cycle stage (broadband NW)**

NOTE – This LCA result cannot be compared with that of another LCA unless all assumptions and modelling choices are equal.

**Table 8-9 – Assessment results by life cycle stage (broadband NW)**

| | Raw material acquisition & Production | Use | End-of-life treatment | Total | Reduction amount |
|---|---|---|---|---|---|
| | $CO_2$ emission [%] | | | | |
| **Reference scenario** | 12 | 75 | 2 | 100 | – |
| **Target scenario** | 2 | 4 | 0.4 | 6 | 94 |

# Appendix I

# Reporting according to tables in Annex L of [ITU-T L.1410]

The following tables have been selected and completed by taking into consideration the goal and scope of this case study. Their numbering follows that of [ITU-T L.1410].

Table L.1 as presented in Annex L of [ITU-T L.1410] shows a cover page completed here to report the results of the case study assessment described in this Supplement.

**Table L.1 of ITU-T L.1410 – Cover page**

| REPORTING | | | |
|---|---|---|---|
| | Yes | No | Description/references to page |
| **General information** | | | |
| Company name and contact information | Yes | | Nippon Telegraph and Telephone Corporation, Japan origuchi.takeshi@lab.ntt.co.jp |
| Project name | Yes | | Example of LCA of the aggregated second order effects of selected ICT services |
| Product system | Yes | | Clause 5.2.2 Scenarios for comparison |
| Product system related information | Yes | | |
| Product system function | Yes | | |
| Product system description | Yes | | |
| Product picture (optional) | | No | |
| Date of completion of assessment (DD/MM/YYYY) | Yes | | 12/09/2016 |
| Compliant with the latest edition of [ITU-T L.1410] | Yes | | ITU-T L.1410 (2014) http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=12207&lang=en |
| LCA tool used | Yes | | Table 6-4 of *Embodied energy and emission intensity data for Japan using input–output tables* [b-3EID, 2000] |
| External review (yes/no) | Yes | | Telecommunication Technology Committee (TTC) in Japan |
| Reviewers | Yes | | |
| **Goal definition** | | | |
| Reason for carrying out the study | Yes | | Introduction Clause 5.2.1 Goal of the study |
| Target audience(s) | Yes | | Open to the public |
| Comparative assessment | Yes | | Clause 5.2.2 Scenarios for comparison |
| **Scope definition** | | | |
| Functional unit | Yes | | Clause 5.2.3 Functional unit |
| Reference flow | Yes | | Clause 6 Data collection |
| System boundaries | Yes | | Clause 5.2.4 System boundaries |
| Environmental impact categories | | | GHG emissions only |
| List of optional and recommended stages considered | | | Not applicable |

**Table L.1 of ITU-T L.1410 – Cover page**

| | | | |
|---|---|---|---|
| Cut-off criteria | Yes | | Clause 5.2.5 Cut-off |
| **Resource used and emission profile** | | | |
| Secondary data sources | Yes | | Clause 7 Data calculation<br>Table 6-3, Table 6-4 |
| Data collection procedure | Yes | | Clause 6 Data collection |
| Technical process flow diagram | | No | These are judged to be unnecessary from the purpose and goal of this case study. |
| Unit process description | | No | |
| Calculation procedure | Yes | | Clause 5.1 Evaluation procedure<br>Clause 7 Data calculation |
| Allocation procedure including the handling of multi functionality | | | Not applicable |
| Data quality | Yes | | Clause 6 Data collection<br>Data for evaluating each scenario was obtained by questionnaire to customer. |
| Data gap | | | Not applicable within the studied system boundary |
| **Environmental impact assessment** | | | |
| Assessment results | Yes | | Clause 8 Results |
| Normalization (optional) | | | Not applicable |
| Weighting (optional) | | | Not applicable |
| **Interpretation** | | | |
| Uncertainty aspects including results from sensitivity analyses | | | Not applicable |
| Conclusion including identification of hot spots | Yes | | Clause 8 Results |

Table L.2 shows the reporting format as presented in [ITU-T L.1410] for included life cycle stages, activities, and generic processes. Table L.2 to Table L.9 have been completed from the viewpoint of the hybrid approach employed in this case study.

**Table L.2 of ITU-T L.1410 – Reporting format for included life cycle stages, activities, and generic processes**

| Tag | Life cycle stage/ Process | Unit process | Included (Yes/No) | Electricity mix (specific/ country/ world average) | Support activities included (Yes/No) | Transport activities included (Yes/No) G1 | Other generic activities included (Yes/No) G2-7 | Motiva -tion/ Comme nt |
|---|---|---|---|---|---|---|---|---|
| A | Goods raw material acquisition | | | | | | | |
| A1 | Raw material extraction | | Yes (mainly based on IOA) | | | | | |
| A2 | Raw material processing | | | | | | | |
| B | Production | | | | | | | |
| B1 | ICT goods production | | Yes (mainly based on IOA) | | | | | |

**Table L.2 of ITU-T L.1410 – Reporting format for included life cycle stages, activities, and generic processes**

| Tag | Life cycle stage/ Process | Unit process | Included (Yes/No) | Electricity mix (specific/ country/ world average) | Support activities included (Yes/No) | Transport activities included (Yes/No) G1 | Other generic activities included (Yes/No) G2-7 | Motiva -tion/ Comme nt |
|---|---|---|---|---|---|---|---|---|
| B1.1 | | Parts production (for further details refer to Annex E of [ITU-T L.1410]) | | | | | | |
| B1.2 | | Assembly | | | | | | |
| B1.3 | | ICT manufacturer support activities | | | | | | |
| B2 | Support goods production | | Partially yes (based on IOA) | | | | | |
| B2.1 | | Support goods manufacturing | Partially yes (based on IOA) | | | | | |
| B3 | ICT-specific site construction | | Yes (data centre) | CO$_2$ emission intensity and user end electricity averaged for 12 electric power companies including distribution loss in FY 2014 | Partially yes | Partially yes (not maintenance transports) | | |
| C | Use | | | | | | | |
| C1 | ICT goods use | | Yes | CO$_2$ emission intensity and user end electricity averaged for 12 electric power companies, including distribution loss in FY 2014 | No | No | No | |
| C2 | Support goods use | | No | | | | | |
| C3 | Operator support activities | | No | Not used | No | No | No | |

**Table L.2 of ITU-T L.1410 – Reporting format for included life cycle stages, activities, and generic processes**

| Tag | Life cycle stage/ Process | Unit process | Included (Yes/No) | Electricity mix (specific/ country/ world average) | Support activities included (Yes/No) | Transport activities included (Yes/No) G1 | Other generic activities included (Yes/No) G2-7 | Motiva -tion/ Comme nt |
|---|---|---|---|---|---|---|---|---|
| C4 | Service provider support activities | | No | | | | | |
| D | Goods end-of-life treatment | | | | | | | |
| D1 | Preparation of ICT goods for reuse | | No | | | | | |
| D2 | ICT-specific EoLT | | | | | | | |
| D2.1 | | Storage/ Disassembly/ Dismantling/ Shredding | Yes (mainly based on IOA) | | | | | |
| D2.2 | | Recycling | | | | | | |
| D3 | Other EoLT | | Yes (mainly based on IOA) | | | | | |

Table L.3 shows the reporting format completed for generic processes for LCAs of ICT goods.

**Table L.3 of ITU-T L.1410 – Reporting format for generic processes for LCAs of ICT goods**

| Generic process | Generic process categories included | Unit processes included (for each generic process category) | Important issues |
|---|---|---|---|
| G1. Transport and travel | Mainly based on IOA | | |
| G2. Electricity | Japan electricity mix | Including distribution losses and fuel supply chain as well as direct emissions | |
| G3. Fuels | Mainly based on IOA | | |
| G4. Other energy | Not applicable | | |
| G5. Raw material acquisition | Mainly based on IOA | | |
| G6. End-of-life treatment | Mainly based on IOA | | |
| G7. Raw material recycling | Mainly based on IOA | | |

Table L.4 shows the reporting format completed for transport/travel.

**Table L.4 of ITU-T L.1410 – Reporting format for transport/travel**

| Mode | CO₂e emission factor (see Note 4) | Raw material acquisition transport | | Production stage transport excluding final transport | | Final transport (see Note 1) (production to use stage) | | Use stage transport | | EoLT transport | | Total transport | | Total travel (see Note 6) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Transport work (see Note 2) {tonne km} | GWP100 {kg CO₂e} (see Note 7) | Transport work {tonne km} | GWP100 {kg CO₂e} | Transport work {tonne km} | GWP100 {kg CO₂e} | Transport work {tonne km} | GWP100 {kg CO₂e} | Transport work {tonne km} | GWP100 {kg CO₂e} | Transport distance (see Note 3) {km} | GWP100 {kg CO₂e} | Travel distance {km} | GWP100 {kg CO₂e} |
| IOA based – Partially included. See cut-off clause 5.2.5 for details. | | | | | | | | | | | | | | | |
| NOTE 1 – The final transport of ICT goods from assembly to operator, including pre- and post-transport connected to the main transport. | | | | | | | | | | | | | | | |
| NOTE 2 – Average in terms of distance, transport mode, load factor, chargeable mass, etc. | | | | | | | | | | | | | | | |
| NOTE 3 – Average in terms of distance, transport mode, load factor, chargeable mass, etc. | | | | | | | | | | | | | | | |
| NOTE 4 – This includes direct fuel consumption and fuel supply chain. | | | | | | | | | | | | | | | |
| NOTE 5 – Specify used transport mode. | | | | | | | | | | | | | | | |
| NOTE 6 – Includes all kinds of travel throughout life cycles, e.g., commuting, business travel and maintenance travel when applicable. Specify travels taken into account. | | | | | | | | | | | | | | | |
| NOTE 7 – Other impact categories to be added as applicable. | | | | | | | | | | | | | | | |

Table L.5 shows the reporting format completed for raw materials.

**Table L.5 of ITU-T L.1410 – Reporting format for raw materials**

| | Total input (g, kg, tonne) | Content in product (see Note 1) (%) | Recycled raw material used (see Note 2) (%) | Recycling of total input (see Note 3) (%) | Reference |
|---|---|---|---|---|---|
| Iron/steel alloys | Included (mainly based on IOA) | | | | |
| Aluminium alloys | | | | | |
| Copper alloys | | | | | |
| Silver | | | | | |
| Gold | | | | | |
| NOTE 1 – Percentage of total input material present in the product after the production process, i.e., total input minus the related production waste. | | | | | |
| NOTE 2 – The amount of recycled raw material used in the production process, this include the raw material contained in the product and the related production waste. | | | | | |
| NOTE 3 – Total recycling of all input materials, i.e., recycling of manufacturing waste and recycling of total content in final product during EOL. | | | | | |

Table L.6 shows the reporting format completed for parts production.

**Table L.6 of ITU-T L.1410 – Reporting format for parts production**

| | Part categories included (see Note 1) | Part unit processes included (see Note 1) | Handling of special issues (see Note 2) |
|---|---|---|---|
| B1.1.1 Batteries | | | |
| B1.1.2 Cables | | | |
| B1.1.3 Electro-mechanics | | | |
| B1.1.4 Integrated circuits (ICs) | | | |
| B1.1.5 Mechanics / materials | Included (mainly based on IOA) | | |
| B1.1.6 Displays | | | |
| B1.1.7 Printed circuit boards (PCBs) | | | |
| B1.1.8 Other PBA components | | | |
| B1.1.9 Packaging materials | | | |
| B1.1.10 Black box modules | | | |
| NOTE 1 – Annex E of [ITU-T L.1410] gives a list of part categories and part unit processes which shall be included when applicable. NOTE 2 – Include description of data source and data set for each part category, e.g., from commercial databases. | | | |

Table L.8 shows the reporting format completed for the end-of-life treatment (EoLT) stage.

**Table L.8 of ITU-T L.1410 – Reporting format for EoLT stage**

| | Process categories included | Process unit processes included | Handling of special issues |
|---|---|---|---|
| D1. Preparation for reuse of ICT goods | Not included | | |
| D2. ICT-specific EoLT | Mainly based on IOA | | |
| D3. Other EoLT | | | |
| NOTE – Annex F of [ITU-T L.1410] gives a list of process categories and unit processes which shall be included when applicable. | | | |

Tables L.7 (Reporting format for use stage energy consumption), L.9 (Reporting format for LCI results), L.11 (Reporting format for network description), L.12 (Reporting format for network energy consumption) and L.13 (Reporting format for service hardware allocation) are not applicable because they come into conflict with industrial secrets.

Table L.10 of [ITU-T L.1410] (Impact category indicators) is not applicable because only $CO_2$ emission is considered in this case study.

# Appendix II

## Compliance with [ITU-T L.1410]

Table XII.1 as presented in Appendix XII of [ITU-T L.1410] has been completed from the viewpoint of the hybrid approach employed in this case study. Table numbering is that of [ITU-T L.1410].

**Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]**

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| Introduction | Deviation(s) from the requirements shall be clearly motivated and reported. | Yes | | |
| 5.2 | Full compliance with [ITU-T L.1410] can be claimed if all mandatory requirements are fulfilled. | | No | Hybrid approach allows for partial compliance only |
| 5.3 | A third-party review is also needed if the comparison result is to be externally communicated. | Yes | | |
| 5.3 | In case of comparative assessment between ICT goods LCAs the operating lifetime shall be set to equal | | | Lifetime of each device is set according to Statutory useful lifetime in Japan [b-Life, 2016]" |
| 6.1 | The requirements of [ITU-T L.1410] shall apply as well as those of [ISO 14040] and [ISO 14044]. | Yes | | |
| 6.1.1 | The following four high-level life cycle stages [raw material acquisition (RMA), production (P), use (U), EoLT] shall apply to ICT goods, networks and services and shall be assessed as applicable in LCAs based on [ITU-T L.1410] in accordance with the goal and scope. | Yes | | |
| 6.1.1 | Table 2 of [ITU-T L.1410] defines the detailed life cycle stages which further defines the system boundary and which are to be considered when assessing the life cycle impact of ICT goods, networks and services. In particular, it is important to cover all processes whose relevance is marked as mandatory in that table. | Yes | | Tables 1-2 and 1-3 |
| 6.1.1 | The data collected shall be structured in such a way that the GHG emissions and energy consumption/environmental impact arising from the transport processes could be reported transparently as far as possible. | | No | Not possible when using IOA data |
| 6.1 | Transport and energy supplies shall be included in all life cycle stages. | Yes | | Except final distribution (See clause 5.2.5) |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 6.1 | At the time of publication, to collect appropriate data related to raw materials transport and to separate data related to raw material acquisition stage and production stage is considered challenging due to LCA tool limitations, lack of data, limitations in data granularity and the nature of ICT supply chains. Deviation(s) from this requirement shall be clearly motivated and reported. | Yes | | IOA based |
| 6.1 | Instances of transport of goods between production and use stages shall be taken into account. | Yes | | IOA based |
| 6.1.2 | The ICT goods, networks and services product system to be assessed shall be clearly described as well as relevant functions and characteristics. | Yes | | |
| 6.1.2.1 | For the ICT good under study, applicable types of parts, as well as amounts of these, shall be defined. | Yes | | IOA based |
| 6.1.2.2 | In the goal and scope phase it shall be outlined which network building blocks are covered. | Yes | | |
| 6.1.2.2 | For the ICT network under study, applicable types of nodes and infrastructure, as well as amounts of these, shall be defined. | | No | Conflict with industrial secrets |
| 6.1.2.3 | For the ICT service under study, applicable types of ICT network elements and infrastructure, as well as amounts of these, shall be defined. | | No | Conflict with industrial secrets |
| 6.1.3.1 | Software shall be considered as well as hardware. | Yes | | IOA based – software included to some extent |
| 6.1.3.1 | For specific software applications, such as music distribution applications, the software is to be seen as an ICT service and shall be assessed according to the requirements outlined for services. | | No | See Table1-3 |
| 6.1.3.1 | In these cases the hardware needed to operate the software shall be considered as well. | | No | See Table1-3 |
| 6.1.3.1 | For users of generic operating systems embedded in products, the life cycle impact of usage of this software may be considered as negligible. However, for the developer of this software the impact of the usage of this software shall be taken into account. | | No | See Table1-3 |
| 6.1.3 | Operating lifetime is critical for the interpretation of the results of LCAs and shall therefore always be reported when presenting LCA results. | Yes | | With some exceptions |
| 6.1.3 | Operating lifetime estimates and assumptions shall also be clearly described in the reporting. | Yes | | |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 6.2.1 | During the LCA scoping phase the building blocks of the ICT goods, networks or services shall be identified. | Yes | | |
| 6.2.2.1 | The functional unit shall be chosen in accordance with the goal and scope of the LCA. | Yes | | |
| 6.2.2.1 | The functional unit requires inclusion of the relevant quantifiable properties and the technical/functional performance of the system. This means that the operating lifetime of all included ICT goods shall be specified. | Yes | | |
| 6.2.2.1 | The number of users/subscribers supported by the network and the traffic profile shall be included where applicable. | Yes | | With some exceptions |
| 6.2.2.1 | The functional unit shall be clearly defined and measurable. | Yes | | |
| 6.2.2.1 | The reference flow shall reflect the functional unit chosen. | Yes | | |
| 6.2.2.2 | The functional unit shall be chosen in the context of goal and scope of the LCA and shall be further clarified by system boundary and cut-off rules. | Yes | | |
| 6.2.2.2 | To comply with [ITU-T L.1410], the following functional unit shall be applied where applicable. Annual ICT goods use (per year of ICT good use), or total ICT good use per lifetime of an ICT good. | Yes | | |
| 6.2.2.2 | For relevant LCA results, realistic use scenarios shall be captured. | Yes | | |
| 6.2.2.3 | ICT networks can be seen as a system composed of different types of ICT goods. For the purposes of [ITU-T L.1410], the following functional unit shall be applied where applicable for ICT networks used during at least 1 year: <br>• annual network use. | Yes | | |
| 6.2.2.3 | For relevant LCA results, realistic use scenarios shall be captured. | Yes | | |
| 6.2.2.4 | For the purposes of [ITU-T L.1410], the following functional unit shall be applied where applicable. annual service use. | Yes | | |
| 6.2.2.4 | For relevant LCA results, realistic use scenarios shall be captured. | Yes | | |
| 6.2.2.4 | Corresponding realistic use scenarios shall be defined. | Yes | | |
| 6.2.2.4 | The annual service use shall be defined with respect to the usage scenario to make it possible to define the reference flow. | Yes | | |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 6.2.3.1 | The selection of the system boundary shall be consistent with the goal of the study. | Yes | | |
| 6.2.3.1 | Consequently, the system boundaries here define the life cycle stages and the unit processes that shall be taken into account in an LCA of an ICT product system. | Yes | | |
| 6.2.3.1 | Table 2 includes further details of the life cycle stages to be included in LCAs of ICT goods, networks and services. The different life cycle stages are further described in clauses 6.2.3.4.2 to 6.2.3.4.5. "Mandatory" in Table 2 means that the life cycle stage shall be included. | Yes | | IOA based |
| 6.2.3.1 | Mandatory life cycle stages or unit processes shall not be cut-off before being considered for inclusion by using alternative data. | Yes | | IOA based |
| 6.2.3.1 | In Table 2 "mandatory" means that the life cycle stage, if applicable to the studied product system, shall always be taken into account in an LCA for ICT. | Yes | | |
| 6.2.3.3.1 | In order to set the system boundary of ICT goods the life cycle stages listed in clause 6.1.1 shall be detailed. | Yes | | IOA based |
| 6.2.3.3.1 | As stated in clause 6.1.3, the environmental impact from both hardware and software shall be considered, if applicable. | Yes | | |
| 6.2.3.3.1 | For the ICT good under study, applicable types of parts, as well as amounts of these, shall be defined. | Not applicable (NA) | | IOA based |
| 6.2.3.3.2 | Table H.1 provides a mandatory set of raw materials (both ICT-specific and generic) which shall be included in the LCA of ICT goods. | NA | | IOA based |
| 6.2.3.3.3 | Annex E lists a mandatory set of parts to be included where applicable to the studied ICT product system, when performing an LCA of ICT goods, as well as mandatory part unit processes which shall be included for each part. | NA | | IOA based |
| 6.2.3.3.3 | As an example, if batteries are part of the studied ICT goods product system they shall be included within the system boundary and for every battery the Battery Cell manufacturing and Battery module manufacturing shall be included. | Yes | | |
| 6.2.3.3.3 | Assembly (B1.2) shall include as minimum PCBA module assembly, final assembly, warehousing, and packaging. | Yes | | IOA based |
| 6.2.3.3.3 | In case support goods are part of the studied product system, support goods Production (B2) is mandatory. | Yes | | With some exceptions, IOA based |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 6.2.3.3.3 | Support goods (B2.1) which shall be included if applicable to the studied product system are at least air conditioners, cables, and power supply systems. | Yes | | With some exceptions, IOA based |
| 6.2.3.3.3 | As stated in Table 2, construction of ICT-specific site (B3) is mandatory if the ICT-specific site is included in the studied product system. | Yes | | |
| 6.2.3.3.3 | Site building blocks to be included in B3.1, if they are applicable to the studied product system, are antenna towers, fences and shelters. | Yes | | |
| 6.2.3.3.4 | Raw material acquisition and Production for the additional PCBAs used during the operating lifetime of the ICT goods are mandatory. | Yes | | IOA based |
| 6.2.3.3.5 | As shown in Figure 11, Preparation of ICT goods for reuse of ICT goods (D1), ICT-specific EoLT (D2) and Other EoLT (D3) are within the mandatory system boundary for EoLT. | Yes | | IOA based |
| 6.2.3.3.5 | Annex F lists a mandatory set of EoLT processes to be included where applicable when performing an LCA of ICT goods which includes the EoLT stage. | Yes | | IOA based |
| 6.2.3.3.5 | It is thus recognized that compliance with all requirements in Annex F may not be possible at the time [ITU-T L.1410] is published. Deviation(s) from the requirements shall be clearly motivated and reported. | Yes | | |
| 6.2.3.4 | The network shall be defined in terms of ICT goods, Support goods and ICT infrastructure (e.g., cables duct). | Yes | | Not described in detail, conflict with industrial secrets |
| 6.2.3.4 | For each included product types, the number of units shall be defined as well as their corresponding lifetimes. | Yes | | not described in detail, conflict with industrial secrets |
| 6.2.3.4 | For the assessment of networks, operator activities shall always be included. | | No | See Table 1-3 |
| 6.2.3.5.1 | In addition to the use of ICT goods and networks, an ICT service may also have additional impacts associated with application software development, use of consumables, infrastructure for sales and logistics, associated travel and transport (in addition to those already included for the ICT goods and networks) which shall also be included as appropriate. | Yes | | Some exceptions such as application Software |
| 6.2.3.5.1 | The impact of the data centres where the service is operated shall be assessed. | Yes | | |
| 6.2.3.5.1 | The data centre shall be studied and assessed in the same way as other ICT goods. | Yes | | |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 6.2.3.5.1 | The system boundary of the ICT services provided by the ICT network shall be established based on either the actual use scenario of the ICT services, if available, or on an estimated use scenario, | Yes | | By customer questionnaire |
| 6.2.3.5.2 | Energy consumption, material inputs and environmental releases shall be assessed in accordance with the system boundary. | Yes | | |
| 6.2.4 | Cut-offs shall be avoided as far as possible. | Yes | | |
| 6.2.4 | The recommendations of clause 4.2.3.3 of [ISO 14044] shall be used as closely as possible. | Yes | | |
| 6.2.4 | All cut-off criteria stated by [ISO 14040] and [ISO 14044] are to be considered before cut-off of a certain process – and the process shall be included if significant to at least one criterion. | Yes | | Not possible to analyse fully for IOA |
| 6.2.4 | The intention of the [ITU-T L.1410] is to include all mandatory activities of Table 2. If these activities are not included, such cut-offs shall be clearly motivated. | Yes | | IOA based |
| 6.2.4 | Any cut-off made shall be clearly described and documented. | Yes | | |
| 6.2.5.1 | A qualitative description of the data quality and any efforts taken to improve it shall be disclosed while considering the following data quality indicators:<br>• Methodological appropriateness and consistency<br>• Completeness (total LCA level)<br>• Uncertainty<br>• Data representativeness<br>• Data age (timeliness)<br>• Acquisition method<br>• Supplier independence<br>• Geographical correlation<br>• Technological correlation<br>• Cut-off rules (rules of inclusion/exclusion) | Yes | | To extent possible for IOA approach |
| 6.2.5.1 | In selecting emission factors for use in calculating GHG emissions under this methodology, the following guidance shall be followed: emission factors used should be the most up to date from publicly available sources. | Yes | | |
| 6.2.5.1 | Where emission factors are sourced from non-public sources, or are not the most up-to-date ones, a justification for their use shall be provided. | Yes | | |
| 6.2.5.1 | The specific global warming potential (GWP) values used shall be those taken from the latest United Nations Intergovernmental Panel on Climate Change (UN IPCC) reports. For further guidance, see Table XI.1. | NA | | IOA based (CO$_2$ only) |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 6.2.5.2 | In general, data age and technology are especially important in LCAs for ICT goods, networks and services due to the fast technology evolution and the growth in network traffic e.g., for data traffic, up-to-date figures shall always be used. | Yes | | |
| 6.2.5.2 | For support activities (e.g., ICT manufacturer support activities and operator support activities), primary data shall be used for all individual processes under the financial or operational control of the organization undertaking the LCA | NA | | IOA based |
| 6.2.5.2 | … and data shall be representative of the processes for which they are collected. | Yes | | IOA based |
| 6.3.1.1 | Data shall be collected for each unit process that is included within the system boundary in accordance with Annex B. | Yes | | IOA based |
| 6.3.1.1 | Data shall be collected for all mandatory processes outlined in Table 2. | Yes | | IOA based |
| 6.3.1.1 | When data has been collected from public sources, the source shall be referenced. | Yes | | |
| 6.3.1.2 | Data shall be collected at least for the processes marked with mandatory in Table 2, unless these are found negligible in accordance with the cut-off rules. | Yes | | IOA based |
| 6.3.1.2.1 | It should be noted that, for many products (especially end-user goods), periods of idling and power off may be significant and are important to consider when modelling the traffic profile/ model the usage profile and shall be included if applicable. | Partially Yes | | |
| 6.3.1.4 | Use time, goods type, data traffic and network access type give important statistical data that needs to be collected in order to quantify the use of ICT systems. | Yes | | |
| 6.3.1.2.3 | When calculating the potential environmental impact the LCA practitioner is encouraged to use the most accurate data for the energy mix that is applicable to the ICT goods under assessment. Particularly the use stage shall use the applicable electricity mix to calculate the potential environmental impact from the use stage more exactly. | Yes | | |
| 6.3.2.1 | The general requirements for data calculations in [ISO 14040] and [ISO 14044] shall be applied. | Yes | | |
| 6.3.2.1 | All calculation procedures shall be explicitly documented and the assumptions made shall be clearly stated and explained. | Yes | | |

**Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]**

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 6.3.2.1 | The same calculation procedures shall be consistently applied throughout the study. | Yes | | |
| 6.3.2.1 | A check on data validity shall be conducted during the process of data collection to confirm that the data quality requirements for the intended application have been fulfilled. | Yes | | |
| 6.3.2.3 | The evaluation of the environmental load shall consider both a fixed part which is independent of the usage and a variable part which correlates to the usage. | Yes | | |
| 6.3.3.1 | The same allocation method shall be used for all environmental loads for all products from a common process. | Yes | | |
| 6.3.3.1 | The study shall identify the processes shared with other product systems and deal with them according to the stepwise procedure presented below. | Yes | | |
| 6.3.3.2 | Data for generic processes (G1 to G7) shall be allocated as a whole (i.e., for the full life cycle for the generic process) to the associated life cycle stage of the product system. | Yes | | |
| 6.3.3.2 | However, all Raw material acquisition (G5) shall be allocated to the life cycle stage Raw material acquisition (A). | | | IOA based (RMA and P are combined) |
| 6.3.3.3 | Data for relevant part of the organization/operation shall be allocated to the relevant part of the project/product system life cycle. | NA | | IOA based |
| 6.3.3.3 | If no detailed information on organization/operation is available, the allocation shall be based on organizational/economic data. | NA | | IOA based |
| 6.3.3.8 | End-user goods (e.g., PCs, smart phones) that access more than one ICT network (e.g., 3G, WLAN) shall be allocated to these ICT networks based on use time. | | No | |
| 6.3.3.8 | The assumptions regarding use time for access to different ICT networks and off line work shall be described and motivated. | Yes | | Based on customer questionnaire |
| 6.3.3.8 | Impact from shared network resources (e.g., transmission goods, core nodes and data centres) shall be allocated to an access network-based on data traffic. | Yes | | |
| 6.3.3.8 | The assumptions regarding data traffic shall be described and motivated. | Yes | | Based on customer questionnaire |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 6.3.3.9 | The impact from each ICT network supporting the service should be allocated to the service based on access use time or data traffic.<br>More specifically, the following allocation principle of ICT network data to an ICT service shall be used:<br>Data for end-user goods: to be allocated based on active use time of the ICT service. etc. | Yes | | |
| 6.3.3.9 | Data traffic is also preferred for e.g., mobile access networks as mobile access networks show a large dependency between data traffic and energy consumption and need a traffic model that takes data traffic into account | Yes | | |
| 6.3.3.9 | Data for data centres and service provider activities:<br>The data centre(s) where the ICT service is operated as well as the service provider activities shall be allocated based on number of subscriptions and service users or amount of data/transactions. | Yes | | |
| 7 | ISO states that the selection of impact categories shall reflect a comprehensive set of environmental issues related to the product system being studied, taking the goal and scope into consideration. | Yes | | |
| 7 | In the LCA it shall be ensured that the inventory elementary flows (see Annex G are correctly linked with appropriate life cycle impact assessment (LCIA) characterization factors. | Yes | | IOA based |
| 7 | For climate change, the most recent global warming characterization factors from the IPCC for each GHG shall be used and the timeframe should be 100 years. | NA | | $CO_2$ only |
| 7 | The midpoint category Climate change is mandatory. | Yes | | |
| 7 | For other impact categories, there is no methodological consensus in the LCA community, thus the practitioner shall decide which impact categories to consider and how to calculate them, based on the studied ICT product system and purpose of the LCA study. | NA | | |
| 7 | All impact categories and category indicators included shall be disclosed (Table L.10) and justified. | Yes | | |
| 8.2 | The sources of uncertainty and methodological choices made shall be assessed and disclosed. | Yes | | |
| 8.3 | The results of the life cycle impact (LCI) or LCIA phases shall be interpreted according to the goal and scope of the study. | Yes | | |
| 8.3 | The interpretation shall include a sensitivity check of the significant inputs, outputs and | Yes | No | |

**Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]**

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| | methodological choices, as well as defined use scenarios, in order to understand the uncertainty of the results. | | | |
| 9.1 | The reporting of ICT product systems shall fulfil the reporting rules as defined by [ISO 14040] and [ISO 14044]. | Yes | | |
| 9.1 | In the case of reporting, a public GHG inventory report, the key accounting principles (relevance, accuracy, completeness, consistency, and transparency) shall be met. | Yes | | |
| 9.1 | In addition to the reporting obligations outlined by [ISO 14040] and [ISO 14044], the report shall include the following information:<br>• contact information<br>• studied goods, networks and services product system name and description<br>• type of inventory (i.e., final product cradle-to-grave or intermediate product cradle-to-gate inventory)<br>• goals of the study.<br>The reporting of results shall include:<br>• total GHG emissions reported as amount of $CO_2e$ per functional unit for ICT good, network and service that have been assessed<br>• percentage for each life cycle stage contributing to the total results<br>• electricity (with use stage separated from the other stages)<br>• primary energy[1]<br>• fuels<br>• value and sources of emission factors for $CO_2$ and $CO_2e$, and GWP metric used in the report<br>• other data, justifications and explanations as stated throughout this report. | Yes | | |
| 9.1 | In addition, the rules outlined in this clause and what is stated in Annex L shall be followed for reporting of studies claiming compliance with [ITU-T L.1410]. | Yes | | |
| 9.1 | The report shall contain a compliance statement saying either that the LCA fully complies with [ITU-T L.1410] (in case of full compliance) or that the LCA partially complies with [ITU-T L.1410] with the exceptions transparently listed and justified (partial compliance). | Yes | | |

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[1] Note that primary energy and electricity cannot be summarized because electricity contributes to the total primary energy.

**Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]**

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 9.1 | The extent to which support activities and other optional/recommended activities are excluded for different parts of the life cycle shall be clearly described and for recommendations also motivated in the study report. | Yes | | |
| 9.1 | For each product system (including ICT goods, networks and services) the following aspects, being of special importance to ICT applications, shall be transparently motivated and described in accordance with the principles defined in this clause: Operating lifetime: All lifetime assumptions shall be stated and motivated. | Yes | | |
| 9.1 | Cut-off: Any cut-off made shall be clearly stated and motivated. | Yes | | |
| 9.1 | Allocations: Basis for allocations made shall be described, especially for recycling, use of recycled materials, distribution of facility data and support activities. | NA | | |
| 9.1 | Data sources: Data sources (i.e., specific/generic) shall be clearly stated, and deviations from Table 2 shall be motivated. | Yes | | |
| 9.1 | For each product system (including ICT goods, networks and services) an additional diagram shall be presented whenever optional activities in Table 2 have been included. | NA | | |
| 9.1 | The emission factors used shall be clearly stated. The source used and the year they represent shall be clearly stated. | Yes | | |
| 9.1 | In the case of emission factors for grid electricity, the source, year and location (specific, country, global average) shall be clearly stated. | Yes | | |
| 9.1 | Where emission factors are sourced from non-public sources, or are not the most up-to-date ones, a justification for their use shall be provided. | Yes | | |
| 9.2.1 | For each impact category studied, diagrams corresponding to Figures 14a and 14b shall be reported for the corresponding category indicator result. | Yes | | |
| 9.2.1 | Due to the importance of operating lifetime to results, information regarding this shall always be present in the diagram, together with some other basic modelling statements including total result for the indicator, LCA study year operating lifetime, etc. as shown below. | Yes | | |
| 9.2.1 | Figure 14b shall be presented whenever optional activities/processes from Table 2 have been included in the studied product system. | Yes | | |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 9.2.1 | For transport, the total result including all transport throughout the life cycle (Table L.4) shall be stated in the immediate proximity of the diagram (Figures 14a and 14b). | Yes | | |
| 9.2.1 | If used data sets do not report transport separately any missing transport shall be listed and motivated. | Yes | | |
| 9.2.1 | Figure 16 shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal". | Yes | | |
| 9.2.1 | A diagram summarizing distribution of selected environmental impact category indicators between life cycle stages shall be prepared together with absolute figures as shown in Table L.10. | No | | $CO_2$ only |
| 9.2.1 | Figure 18 shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal". See further explanation in the scope. | | No | Conflict with industrial secrets |
| 9.2.2.1 | Any deviation from Table 2 and clause 6.2.3 with respect to mandatory life cycle stages/unit processes shall be clearly stated and motivated. | Yes | | |
| 9.2.2.1 | Additionally, inclusion of generic processes for the different life cycle stages shall be clearly stated and reported. | Yes | | IOA based |
| 9.2.2.1 | Deviations for Generic processes shall be reported according to Table L.3. | Yes | | IOA based |
| 9.2.2.2 | The use of raw materials shall be transparently reported as outlined below. | Yes | | IOA based |
| 9.2.2.2 | The most important metals from recycling point of view shall always be included. For an appropriate reporting format refer to Table L.5. | Yes | | |
| 9.2.2.2 | Deviation(s) from the requirements shall be clearly motivated and reported. | Yes | | |
| 9.2.2.3.1 | Compliance with Table E.1 shall be reported and any deviation shall be described and motivated. For an appropriate reporting format refer to Table L.6. | Yes | | |
| 9.2.2.4.1 | Compliance with Table E.1 shall be reported and any deviation shall be described and motivated. For an appropriate reporting format refer to Table L.6. | Yes | | |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 9.2.2.4.1 | The model of distribution over time of different usage modes including power off and idle and the rationale for those shall be transparently reported. For an appropriate reporting format refer to Table L.7. | NA | | |
| 9.2.2.4.2 | The rationale for the energy consumption values for the support goods use shall be transparently described and motivated. For an appropriate reporting format refer to Table L.7. | Yes | | |
| 9.2.2.5 | If EoLT is included, any deviations from Annex F shall be transparently reported and motivated. For an appropriate reporting format refer to Table L.3. | Yes | | |
| 9.2.3 | For LCI the following items shall be reported transparently: total use of primary energy and electricity. | Yes | | |
| 9.2.3 | Additionally, results for elementary flows according to Table G.1 could be transparently reported on an optional basis. If such reporting is not made it is mandatory to describe unexpected results, lack of data, and other findings associated with the elementary flows. | NA | | |
| 9.3.1 | Operating lifetime is important also for networks, but is associated with the lifetime of the different nodes, which shall be reported. | Yes | | Not described in detail, conflict with industrial secrets |
| 9.3.1 | It shall be reported following the format of Annex L (Table L.11) which also describes the studied network. | | No | Conflict with industrial secrets |
| 9.3.1 | Figure 18 shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal". | | No | Conflict with industrial secrets |
| 9.3.1 | Additionally, a diagram summarizing distribution of environmental impact category indicators between life cycle stages shall be prepared together with absolute figures as shown in the Annex L (Table L.10). | No | | $CO_2$ only |
| 9.3.1 | Figure 19 shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal". | NA | | |
| 9.3.1 | Details of network energy consumption shall be reported with a split of different elements of the network. An example of Table for Reporting is provided in Table L.12. | | No | Conflict with industrial secrets |
| 9.4.1 | Operating lifetime is important also for services, but it is associated with the lifetime of the different nodes, which shall be reported. | | No | Conflict with industrial secrets |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 9.4.1 | Allocation of network data to the service shall be reported. It should be reported according to Table L.13 . | | No | Conflict with industrial secrets |
| 9.4.1 | Additionally, a diagram summarizing distribution of impact category indicators between life cycle stages for the service product system under study shall be presented together with absolute figures as shown in Table L.10. | No | | $CO_2$ only |
| 9.4.1 | Figure 22 shall be accompanied by the disclaimer "This LCA result cannot be compared to the result of another LCA unless all assumptions and modelling choices are equal". | | No | Conflict with industrial secrets |
| 10 | Any critical review shall be performed according to the requirements of [ISO 14040], [ISO 14044] and [ITU-T L.1410]. | Yes | | |
| 10 | The scope and type of critical review desired shall be defined in accordance with clauses 4.2.3.8 and 6 of [ISO 14044]. | Yes | | |
| 11.1 | Infrastructure, e.g., highways for transportation, is generally assumed to exist independently of introduction of new services and shall be excluded. | NA | | |
| 11.1 | The handling of time perspective and scale shall be disclosed and motivated in the report. | Yes | | |
| 11.1 | To be able to quantify the net environmental impact when introducing an ICT based service the environmental impact of both the ICT service itself and of the reference product system need to/shall be assessed from a life cycle perspective. | Yes | | |
| 11.1 | To make sure that the comparative assessment gives a relevant result, the full life cycle of both systems shall always be considered | Yes | | |
| 11.1 | From an LCA perspective the reference product system and the ICT service based system shall mimic each other as far as possible | Yes | | |
| 11.1 | and the practitioner shall model both systems in an unbiased way. | Yes | | |
| 11.2 | Goods shall be compared with other goods | Yes | | |
| 11.2 | ICT networks shall be compared between themselves. | Yes | | |
| 11.2 | ICT services shall be compared between themselves. | Yes | | |
| 11.3.1 | In this comparative LCA study, the scope of the LCA study shall be defined in such a way that the two systems can be compared. | Yes | | |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| 11.3.1 | Systems shall be compared using the same functional unit and equivalent methodological considerations, such as performance, system boundary, data quality, allocation procedures and cut-off rules. | Yes | | |
| 11.3.1 | Any differences between systems regarding these parameters shall be identified and reported. | Yes | | |
| 11.3.2 | Also in this case, the scope of the LCA study shall be defined in such a way that the two systems can be compared. | Yes | | |
| 11.3.2 | Both systems shall be assessed using the same functional unit and equivalent methodological considerations, such as performance, system boundary, data quality, allocation procedures and cut-off rules. | Yes | | |
| 11.3.2 | Any differences between systems regarding these parameters shall be identified and reported. | Yes | | |
| 11.3.3 | The assessment of the ICT based system shall be performed in accordance with Part I. | Yes | | |
| 11.3.3 | When making comparisons, it is important to keep in mind that the functional unit used shall be applicable to both the reference product system and the system of ICT goods, networks and services. | Yes | | |
| 11.3.3 | For the reference product system, applicable requirements in [ITU-T L.1410] shall be applied, e.g., requirements regarding data quality and cut-off. | Yes | | |
| 12.2 | All the requirements stipulated in Part I for a system boundary definition shall be applied. | Yes | | |
| 12.2.1 | The functional unit shall take into account the general rules outlined in Part I, clause 6.2.2 "Functional unit" and clause 4.2.3.2 of [ISO 14044]. | Yes | | |
| 12.2.1 | Additionally, the functional unit shall be defined so that it is applicable both to the ICT goods, networks and services product system and the reference product system. | Yes | | |
| 12.2.1 | The reference flow shall be defined to quantify the functional unit. | Yes | | |
| 12.2.1 | In other words, for the functional unit of one meeting, for instance, the reference flow for the systems of ICT goods, networks and services and the reference product system shall be defined. | Yes | | |
| 12.2.2 | Two different system boundaries shall be defined which are applicable for the ICT goods, | Yes | | |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| | networks and services product system and for the reference product systems, respectively. | | | |
| 12.2.2 | Considerations shall be made to which electricity is used when assessing the environmental impact of the ICT goods, networks and services product system, and the reference product systems. | Yes | | |
| 12.3 | The calculation for the inventory analysis shall be performed in accordance with Part I, clause 6.3. | Yes | | |
| 12.4 | The calculation for the inventory analysis shall be performed in accordance with Part I, clause 6.3. | Yes | | |
| 13 | Any cut-off made during a study shall be clearly stated in the study report, e.g., the exclusion of life cycle processes which are considered insignificant should be justified. | Yes | | |
| Annex B | A mandatory list of generic activities (unit processes) that have been found to be of importance for LCA of ICT goods, networks and services can be found in Annex D. | NA | | IOA based |
| Annex B | The following emissions shall be taken into account if applicable to the studied impact category(ies): <br>• emissions to air; <br>• emissions to water; <br>• emissions to soil. | NA | | |
| Annex B | The following resource objects shall be taken into account if applicable to the studied impact category(ies): <br>• material resource use (or material depletion); <br>• energy resource use (or energy resources depletion). | NA | | IOA based |
| Annex B | A list of emissions and resource objects that shall be included, if applicable to the studied product system and impact category(ies), can be found in Table G.1. | NA | | |

## Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| Annex B | Furthermore, the following inputs shall also be included if applicable to the studied impact category(ies):<br>• electricity;<br>• other forms of delivered energy (district heating and cooling);<br>• fuels (typically indicates the fuels are incinerated on-facility or in a vehicle connected to the facility);<br>• primary products (products that are part of the final product in operation);<br>• secondary products (products that are not part of the final product in operation);<br>• transport, travel, and other services (can be seen as a special non-material secondary product input). | Yes | | IOA based |
| Annex B | Finally, the following flows shall also be included if applicable to the studied impact category(ies):<br>• water discharge (to municipal sewage or recipient);<br>• waste fractions (residual waste fractions or waste fractions that need further treatment, also including material recycling and energy recovery);<br>• product output (the main purpose with the unit process or activity). | NA | | |
| Annex C | Any support activities included in the LCA scope shall be clearly reported in terms of organization activities considered. | No | | |
| Annex C | G7….Other material shall be considered | NA | | |
| Annex E | Table E.1 lists the applicable parts and assembly types which shall be taken into account when performing an LCA of ICT goods, if applicable to the ICT good (not ICT network). It also lists the corresponding part and assembly categories and unit processes. | Yes | | IOA based |
| Annex G | Table G.1 contains elementary flows which shall be taken into account in LCA analyses for ICT. | Yes | | IOA based |
| Annex G | The substance names listed in Table G.1 shall be used in the report. | NA | | |
| Annex G | Deviation(s) from the requirements shall be clearly motivated and reported. | Yes | | |
| Annex H | Table H.1 lists the minimum raw materials groups (chemicals, fuels, metals, plastics, packaging materials and additives) that shall be taken into account in LCAs of ICT goods, if applicable to the studied ICT product system. | Yes | | IOA based |

**Table XII.1 of ITU-T L.1410 – Summary of requirements of [ITU-T L.1410]**

| Clause in [ITU-T L.1410] | Requirement of [ITU-T L.1410] | Fulfilled | Not fulfilled | Explanation/ motivation if not compliant |
|---|---|---|---|---|
| Annex L | This annex contains tables that shall be used to report the result of the assessment. | Yes | | |
| Annex L | Deviation(s) from the requirements shall be clearly motivated and reported. | Yes | | |

# Appendix III

# Questionnaire

## III.1 Questionnaire 1

The questionnaire results for selection of target scenarios and reference scenarios follow.

| Function | Target scenario | | Reference scenario | |
|---|---|---|---|---|
| | **ID** | | **ID** | |
| Talk with someone | t1 | Voice calls | r1.1 | Use home telephone |
| | | | r1.2 | Use public telephone |
| | | | r1.3 | Meet |
| | | | r1.4 | Do nothing |
| Transmit messages | t2 | Email | r2.1 | Use home telephone |
| | | | r2.2 | Use public telephone |
| | | | r2.3 | Letter |
| | | | r2.4 | Fax |
| | | | r2.5 | Meet |
| | | | r2.6 | Do nothing |
| Listen to music | t3 | Music | r3.1 | Purchase CD |
| | | | r3.2 | Rent CD |
| | | | r3.3 | Watch TV, listen to radio |
| | | | r3.4 | Do nothing |
| Set smartphone wallpaper | t4 | Images | r4.1 | Do nothing |
| Play games | t5 | Games | r5.1 | Purchase game software |
| | | | r5.2 | Rent game software |
| | | | r5.3 | Play at arcade |
| | | | r5.4 | Do nothing |
| Read and watch entertainment and sports news | t6 | Entertainment and sports news | r6.1 | Watch TV, listen to radio |
| | | | r6.2 | Read books, magazines |
| | | | r6.3 | Read newspaper |
| | | | r6.4 | Read hanging poster |
| | | | r6.5 | Do nothing |
| Search for information | t7 | Search and link aggregation | r7.1 | Search in library |
| | | | r7.2 | Search with books to hold |
| | | | r7.3 | Purchase books, magazines |
| | | | r7.4 | Use telephone to ask |
| | | | r7.5 | Meet and ask |
| | | | r7.6 | Do nothing |

| Function | Target scenario | | Reference scenario | |
|---|---|---|---|---|
| | **ID** | | **ID** | |
| Get unspecified number of opinions | t8 | Bulletin boards | r8.1 | Use bulletin board in town block |
| | | | r8.2 | Use interchange column of newspaper, magazine |
| | | | r8.3 | Use telephone to ask |
| | | | r8.4 | Meet and ask |
| | | | r8.5 | Do nothing |
| Share own information with public | t9 | Personal websites | r9.1 | Use telephone |
| | | | r9.2 | Letter |
| | | | r9.3 | Meet and talk |
| | | | r9.4 | Use bulletin board in town block |
| | | | r9.5 | Do nothing |
| Share own opinion with public | t10 | Blogs | r10.1 | Use telephone |
| | | | r10.2 | Letter |
| | | | r10.3 | Meet and talk |
| | | | r10.4 | Use bulletin board in town block |
| | | | r10.5 | Do nothing |
| Exchange information with colleague | t11 | SNS | r11.1 | Use telephone |
| | | | r11.2 | Letter |
| | | | r11.3 | Meet and talk |
| | | | r11.4 | Use bulletin board in town block |
| | | | r11.5 | Do nothing |
| Watch paid video | t12 | Paid video | r12.1 | Watch TV |
| | | | r12.2 | Purchase DVD |
| | | | r12.3 | Rent DVD |
| | | | r12.4 | Do nothing |
| Watch free video | t13 | Free video | r13.1 | Watch TV |
| | | | r13.2 | Do nothing |
| Obtain information on food, drinks, shopping etc. | t14 | Dining information | r14.1 | Look through yellow pages |
| | | | r14.2 | Read books, magazines |
| | | | r14.3 | Watch TV, listen to radio |
| | | | r14.4 | Read newspaper |
| | | | r14.5 | Do nothing |
| Read books and magazines | t15 | Digital books | r15.1 | Purchase books, magazines |
| | | | r15.2 | Borrow books in a library |
| | | | r15.3 | Use internet cafe |
| | | | r15.4 | Do nothing |

| Function | Target scenario | | Reference scenario | |
|---|---|---|---|---|
| | **ID** | | **ID** | |
| Check communication fees | t16 | Call carrier sites | r16.1 | Do nothing |
| Obtain terminal information | t17 | Call phone manufacturer sites | r17.1 | Do nothing |
| Obtain route guidance | t18 | Map | r18.1 | Ask a person |
| | | | r18.2 | Purchase map (paper) |
| | | | r18.3 | Do nothing |
| Obtain traffic information and train/bus schedules | t19 | Transportation information and time schedules | r19.1 | Use train/bus schedules (paper) |
| | | | r19.2 | Call and ask the station |
| | | | r19.3 | Do nothing |
| Read and watch general news | t20 | General news | r20.1 | Watch TV, listen to radio |
| | | | r20.2 | Read newspaper |
| | | | r20.3 | Read magazines |
| | | | r20.4 | Ask a person |
| | | | r20.5 | Do nothing |
| Obtain weather information | t21 | Weather reports | r21.1 | Watch TV, listen to radio |
| | | | r21.2 | Read newspaper |
| | | | r21.3 | Use weather forecasting telephone service |
| | | | r21.4 | Do nothing |
| Use banking service | t22 | Online banking | r22.1 | Go to bank |
| | | | r22.2 | Use ATM nearby |
| | | | r22.3 | Use telephone banking service |
| | | | r22.4 | Do nothing |
| Purchase books and magazines | t23.1 | Online shopping (books, magazines) | r23.1 | Purchase in shop |
| | | | r23.2 | Order on telephone |
| | | | r23.3 | Order by postcard |
| | | | r23.4 | Do nothing |
| Purchase CD and DVD | t23.2 | Online shopping (CD, DVD) | r23.5 | Purchase in shop |
| | | | r23.6 | Order on telephone |
| | | | r23.7 | Order by postcard |
| | | | r23.8 | Do nothing |
| Purchase food, liquor, and drinks | t23.3 | Online shopping (food, liquor, drinks) | r23.9 | Purchase in shop |
| | | | r23.10 | Media shopping on TV, radio |
| | | | r23.11 | Mail order with catalogues |
| | | | r23.12 | Home delivery service |
| | | | r23.13 | Do nothing |

| Function | Target scenario | | Reference scenario | |
|---|---|---|---|---|
| | **ID** | | **ID** | |
| Purchase clothes and accessories | t23.4 | Online shopping (clothes, accessories) | r23.14 | Purchase in a shop |
| | | | r23.15 | Media shopping on TV, radio |
| | | | r23.16 | Mail order with catalogues |
| | | | r23.17 | Do nothing |
| Buy and sell used goods | t24 | Auctions | r24.1 | Free market, bazaar |
| | | | r24.2 | Recycle shop |
| | | | r24.3 | Personal trading |
| | | | r24.4 | Do nothing |
| Apply for prize | t25 | Awards, questionnaires | r25.1 | Postcard |
| | | | r25.2 | Telephone |
| | | | r25.3 | Do nothing |
| Obtain discount coupon | t26 | Bargains, discount coupons | r26.1 | Leaflet |
| | | | r26.2 | Direct mail |
| | | | r26.3 | Information magazine, free newspaper |
| | | | r26.4 | Do nothing |
| Obtain stock market information | t27 | Stocks, market information | r27.1 | Watch TV, listen to radio |
| | | | r27.2 | Read newspaper |
| | | | r27.3 | Use electric bulletin board in street |
| | | | r27.4 | Visit stock company |
| | | | r27.5 | Call and ask stock company |
| | | | r27.6 | Do nothing |
| Obtain miscellaneous information and culture | t28 | Miscellaneous information and culture | r28.1 | Correspondence education |
| | | | r28.2 | Go to school |
| | | | r28.3 | Purchase books, magazines |
| | | | r28.4 | Borrow books from library |
| | | | r28.5 | Do nothing |
| | Number of target scenarios: 28 | | Number of reference scenarios: 121 | |

## III.2   Questionnaire 2

As an example, the questionnaire result for the target scenario "music" follows.

(1) User ratio of each target scenario

Q: What kind of service do you usually use?

A:

| Function | Target scenario | | User ratio [%] |
|---|---|---|---|
| Listen to music | t3 | Music | 41.7 |

Q: What is an alternative way that you listen to music with your mobile phone?

A:

| Function | Reference scenarios | | User ratio [%] |
|---|---|---|---|
| Listen to music | r3.1 | Purchase CD | 23 |
| | r3.2 | Rent CD | 54 |
| | r3.3 | Watch TV, listen to radio | 12 |
| | r3.4 | Do nothing | 11 |

(2) Use frequency

Q: How often do you use mobile phone music services?

A:

| | More than 5 times a day | 2 – 4 times a day | Once a day | Once a week | Less than once a month | Do nothing |
|---|---|---|---|---|---|---|
| Number of selectors [person] | 6 | 14 | 34 | 86 | 347 | 682 |

(3) Time of use

Q: How long do you use the service per use?

A:

| | More than 1 hour | 30 min – 1 hour | 10 – 30 min | 5 – 10 min | 1 – 5 min | Less than 1 min |
|---|---|---|---|---|---|---|
| Number of selectors [person] | 40 | 50 | 109 | 114 | 110 | 64 |

(4) Means of transportation to store and distance

Q: What is your means of transportation to the store? What is the distance to the store?

A:

| | On foot, bicycle | Motorcycle | Automobile | Bus | Railway |
|---|---|---|---|---|---|
| Distance [km] | 4.49 | 1.06 | 15.00 | 4.46 | 18.85 |

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